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ABSTRACT

This activity book is part of a series designed to take a concept or idea from the existing school curriculum and develop it in the context of the Great Lakes using teaching approaches and materials appropriate for students in middle and high school. The subject of this book is environmental issues in the Great Lakes. Students learn about the relationships between population, resources and waste. Activities are divided into several subjects: (1) Resources and Reactions; (2) Great Lakes Water Quality (Toxins); (3) Watershed and Basin Issues; and (4) Oil Pollution. The activities are characterized by subject matter compatibility with existing curriculum topics. Several kinds of connections have been designed to assist teachers in finding the place where the new materials fit and also the justification for fitting them. The connections include a Framework of Seven Understandings developed by science teachers, science educators, and scientists to represent fundamental desired results of science education. Each activity in this book addresses a number of these Understandings and two or more Earth subsystems. Connections are also made to the National Science Education Standards and the Benchmarks for Science Literacy. (PVD)

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ED 419 671

GREAT LAKES ENVIRONMENTAL ISSUES

ES-EAGLS

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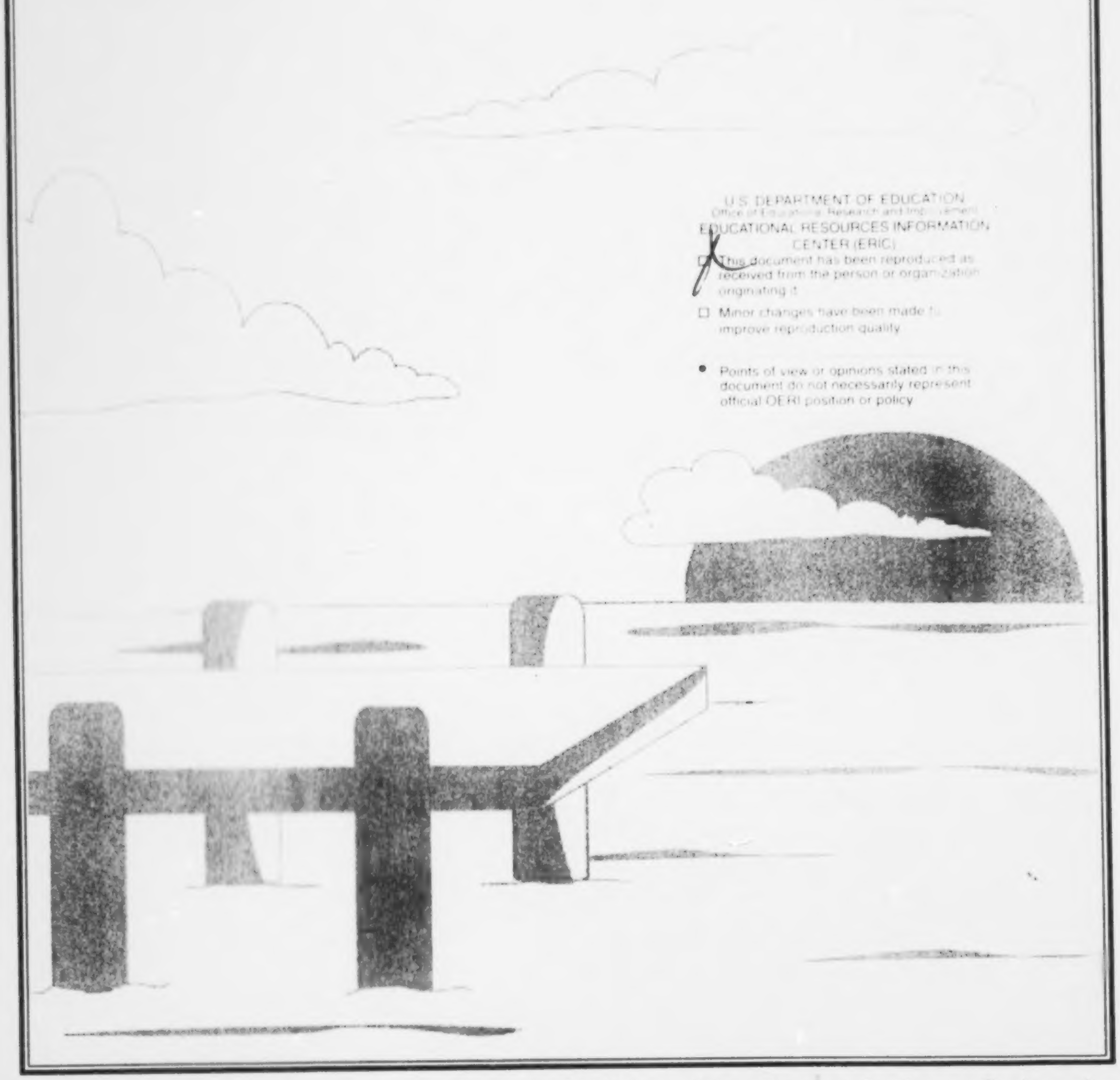

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Earth Systems — Education Activities for Great Lakes Schools

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The Ohio Sea Grant College Program is one of 29 state programs that works to increase understanding and wise use of the nation's ocean and Great Lakes resources. Projects are conducted in partnership with government, academia, industry, and the general public. Sea Grant fulfills its mission by promoting education excellence, responsive research and training, and broad, prompt dissemination of knowledge and technical information.

Earth Systems - Education Activities for Great Lakes Schools (ES-EAGLS)

This series of publications was produced as a result of Ohio Sea Grant Education Program's project "Cooperative Curriculum Enhancement and Teacher Education for the Great Lakes" funded by Ohio Sea Grant under grant NA46RG0482, project E/CMD-3, with support from The Ohio State University and cooperating schools.

ES-EAGLS are designed to take a concept or idea from the existing school curriculum and develop it in a Great Lakes context appropriate for students in middle and high school.

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ES - EAGLS

Earth Systems - Education Activities for Great Lakes Schools

Results of studies of student knowledge about the oceans and Great Lakes environments indicate a need for greater awareness and a greater understanding of the impact they have upon our lives. Earth Systems - Education Activities for Great Lakes Schools (ES-EAGLS) are designed to take a concept or idea from the existing school curriculum and develop it in a Great Lakes context, using teaching approaches and materials appropriate for students in middle and high school.

The activities are characterized by subject matter compatibility with existing curriculum topics; short activity time lasting one to three classes; minimal preparation time; minimal equipment needs; standard page size for easy duplication; suggested extension activities for further information or creative expression; teachability demonstrated by use in middle school classrooms; and content accuracy assured by critical reviewers.

Included with the activities are some suggestions about possible ways to use the activities in cooperative learning situations and how lessons can be structured according to the learning cycle.

This is one of a series of subject area activity books being published. The subject of this book is environmental issues in the Great Lakes. Other subject areas available are land/water interactions, climate and water movement, Great Lakes ecology, and Great Lakes shipping. For a more detailed listing of the environmental issues activities, see the matrix on page 7. Most of the activities in this book were modified from Oceanic Education Activities for Great Lakes Schools (OEAGLS), developed by the Ohio Sea Grant Education Program and revised from 1985 to 1991. All ES-EAGLS are listed inside the back cover.

GREAT LAKES ENVIRONMENTAL ISSUES

INTRODUCTION

Using *ES-EAGLS Life in the Great Lakes* 2
Making Connections 6
Earth Systems Education, National Science Education Standards, Benchmarks
Other Connections 10
Arts and Literature of the Great Lakes 13

ACTIVITIES

Resources and Reactions

How big is a crowd? 15
Who owns the resources of the Great Lakes? 19
How (environmentally) insulting can we get? 25
How skillfully can you read science articles? 29

Great Lakes Water Quality

Background and Issues 43
How much is one part per million? 45
Which fish can we eat? 49
How should the public health be protected? 57
How do toxins move through the food chain? 71
Toxic Chemicals in the Great Lakes 77
Where do all the toxins go? (Internal View) 87
Where do all the toxins go? (External View) 90
Could we live without chlorine in the Great Lakes? 99

Watershed and Basin Issues

What can we learn about water quality in a river? 125
What happens when nutrients enter an estuary? 145
What is the status of the Great Lakes Areas of Concern? 155

Oil Pollution

Where does oil pollution come from? 161
How can an oil spill be cleaned up? 167
How does an oil spill affect living things? 171
What if...? (A Great Lakes investigation) 177

APPENDIX

Framework for Earth Systems Education 179
Sample Rubric 180

Using *ES-EAGLS Great Lakes Environmental Issues*

An accompanying matrix (page 7) matches activities to the Earth Systems Understandings (ESU) and the Earth subsystems directly addressed (hydrosphere, lithosphere, cryosphere, biosphere, atmosphere). It demonstrates the range of instructional opportunities available for the classroom.

The principles that guided development of the activities should also direct their classroom use:

- Potential for collaborative learning and group decision making.
- Use of historical and descriptive as well as experimental data.
- Integration of science disciplines in a social context.

It is recommended that the format for the activities be retained when they are used in the classroom. Some short activities are designed for introduction to topics or for awareness. Longer activities focus attention for extended work and are designed to build understanding, synthesis, application, and evaluation skills. The extent and focus of the activities will help teachers decide which are useful in cooperative groups and which are best for use by the class as a whole.

1. Each activity is a question to be explored. Far too many classroom activities are done for the sake of activity alone. If an important and relevant question is the guide for learning, there is greater focus and a readily apparent reason for doing the activity. Be sure to call students' attention to the question driving the exploration and encourage creative approaches to problem solving.

2. Most activities are addressed to the student for direct use. Additional notes and answers for teacher use are found in narrow columns on each page so they can be concealed if the page is to be given to students.

3. Activities do not stand alone. They should be linked, before and after, to other curriculum topics and information resources such as the Internet. The best questions are those that lead to more questions!

COOPERATIVE LEARNING POSSIBILITIES

There are many ways to organize the activities with cooperative learning strategies, and all of them are the "right way." You are encouraged to modify strategies to make the activities work in your setting. Some possible strategies follow.

GROUPS

Divide the class into three or four groups, with each responsible for certain tasks that will contribute to class learning. Assign each group member a job or task appropriate to the lesson. They are then responsible to the group for doing this job. Jobs can be combined, and they should be rotated between group members periodically. Some possible job descriptions are:

Facilitator	Develops a plan with the group so that the group will finish within the time limit.
Recorder	Records plan, answers, and conclusions as appropriate.
Reader	Reads instructions and background material to group.
Artist	Sketches diagrams, posters, and charts as appropriate.
Checker	Checks to make sure the group is following instructions and the plan.
Speaker	Shares group progress report with class.
Materials Expert	Gets lab materials and makes sure things are cleaned up and returned.

JIGSAW

Divide the class into groups of four students each. These are the base groups. Then divide the class differently into four expert groups. One person from each base group will be in each of the four expert groups. (You will need to adjust the numbers of groups depending on your class size.) Each student should be in two groups. Instead of having every student doing all activities, you can assign each expert group a different activity or task that they become experts at. Then have students meet in their base group and share what was done in the expert group and what was learned. Or you could have the expert groups do their activities and then have the base groups rotate through the activities with the "expert" members leading their base groups through the activity.

STUDENT TEAMS ACHIEVEMENT DIVISIONS

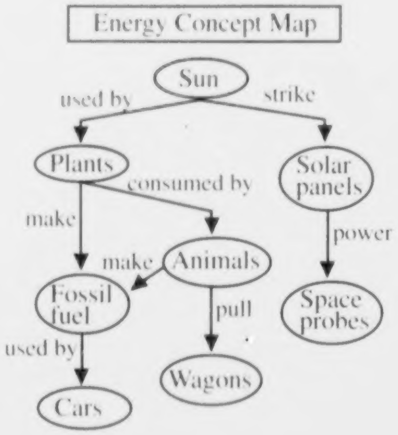
After some type of class presentation such as a lecture, video, or textbook reading, students are divided into teams. Students on the teams work together to make sure that all members of the team understand the material of the presentation. The students then take a quiz individually. Students have a minimum desired score, and the team works to get a high team improvement score (points above the minimum desired score). For more information about this strategy, read *Using Team Learning* by Robert Slavin (Baltimore: The Johns Hopkins Team Learning Project, 1986).

CO-OP CO-OP

This strategy is very student-directed. Students are in teams based on shared interest. The teams subdivide their topics, and all students are responsible for researching their own subtopics. They then share what they have learned about the subtopic with their whole team. The teams then prepare a presentation for the entire class, and they are encouraged to include the class in the presentation in some way. *Cooperative Learning: Resources for Teachers*, by Spencer Kagan (Riverside, CA: University of California, 1985) will provide you with more information about this strategy.

ASSESSMENT STRATEGY: CONCEPT MAPPING

Concept mapping is one way of having students show visually their understandings of concepts and the concepts' relationships to each other. This can be done as a pre-assessment or a post-assessment or both to see the change in a student's understanding. A brief strategy for use of concept mapping would be to brainstorm a list of terms that students know about a topic. Add terms that you want to make sure are included. Have students start with the topic at the top or center of a sheet of paper, and then, using arrows and labels, students place the brainstormed terms on the map, showing how they are related. See the example of a student's preliminary energy concept map.


Energy Concept Map

There are many other ways of assessing student achievement, including performance assessment, portfolios, and grading rubrics. To learn more about these strategies you might read:

Aronson, J. 1978. *The Jigsaw Classroom*. Beverly Hills: Sage.

Hassard, Jack. 1990. Cooperating Classroom. *Science Scope*. March, p. 36-45.

Johnson, D.W., R.T. Johnson and E.J. Holubec. 1986. *Circles of Learning: Cooperation in the Classroom*. Edina, MN: Interaction Book Company.

Mayer, V.J. and R.W. Fortner, Eds. 1995. *Science is a Study of Earth - A Resource Guide for Science Curriculum Restructure*. Columbus, OH: Earth Systems Education Program, The Ohio State University.

Special Supplement on Assessment. March, 1992. *Science Scope*. This issue contains articles on performance assessment, portfolios, group assessment, concept mapping, and rubrics.

EXAMPLE COOPERATIVE LESSONS

Example 1: Toxins in the Great Lakes: micro- and macro- level issues.

Engagement

As a class discuss what is known about toxic substances in the Great Lakes. List the names of chemicals known by students and discuss their awareness of the effects of the compounds on humans and wildlife. Read a current article of your choice about an incident of toxic contamination and its impact.

Exploration

Jigsaw: Divide the class into two expert groups for completing one of the following activity sets. Each expert group will redivide into smaller groups to complete related activities.

Micro level activities: Toxins are an important issue at the organism level. Students in the micro-level expert group will investigate "How many is one part per million?"; "Which fish can we eat?"; and "Where do all the toxins go? (Internal View)."

1. Identify group leader. Obtain materials.
2. Discuss each of the objectives of the activities.
3. Divide into three smaller groups, with each group completing one of the activities listed; then regroup to discuss the important concepts.
4. Decide what information from each activity will be shared with your base groups.
5. The following could be added to the information provided to base groups: After doing an Internet search, present a discussion of the concentration levels of toxins deemed safe for humans and wildlife compared to some of the different levels of contaminants in the Great Lakes region. Add information about the factors that cause some fish to have higher concentrations of contaminants than others (i.e., species, size, location, etc.).

Macro-level activities: It is important to consider the effects of toxins at the ecosystem and regional level, which will eventually affect organisms. Members of the macro expert group will investigate "How big is the problem of airborne toxins?" and "Where do all the toxins go? (External View)."

1. Identify group leader. Obtain materials.
2. Discuss each of the objectives of the activities.
3. Divide into two smaller groups, with each group completing one of the activities; then regroup to discuss the important concepts.
4. Decide what information from each activity will be shared with your base groups. For example, in base groups, students conduct procedure 6 in "How big is the problem of airborne toxins?" as a model of how far various pollutants can travel by air. Members of base groups can also complete Procedure 2 of "Where do all the toxins go? (External View)" with the help of the expert group members who completed the activity.

Elaboration

As a class, do the following to complete the jigsaw:

1. Combine groups together into new (base) groups of eight or more members (at least one from each expert group). Students should discuss the activities with one another and share what they learned in expert groups.
2. Choose one of the two role-play activities for the class to do together: "Should chlorine be banned from the Great Lakes?" or "How should the public health be protected?" Assign a role from the activity to each base group member. Students assigned the same role should meet to discuss how they want to present their arguments. After members have read their role descriptions, conduct the role play and decide on a course of action based on the proposals of participants.

Evaluation

1. Assign an Environmental Issues Portfolio Element. In the activities of this session, students have encountered micro- and macro- level issues involving toxins in the Great Lakes. Using the concepts of the activities, they are to create a concept map showing the relationships between the topics from a macro to a micro scale. The activity "Where do all the toxins go? (External View)" is a starting place, and students should incorporate macro concepts into their previously constructed food chains.
2. Develop a process rubric for use in scoring student performance. A sample rubric is given in the appendix of this volume.

Example 2: What is the status of our Areas of Concern?

This activity offers excellent cooperative learning opportunities for jigsaw processes. Student collaborative groups (3-5 groups of students) can become experts on any of the following and can then share their expertise with other groups as they seek answers to the questions:

- What are the characteristics of the watersheds for each of the Great Lakes? How are land uses in watersheds related to the numbers (or types of contaminants) of Areas of Concern on the lakes?
- What types of contaminants are prominent in Areas of Concern? Why are these contaminants a problem (what are their human, wildlife, and ecosystem effects)?
- How is Remedial Action Planning different among Areas of Concern that are rural versus those that are urban? That is, who is involved, what strategies are in place? How much progress has been made?

Making Connections

There is always a danger in producing curriculum materials designed for infusion. How can we facilitate getting new material into the existing flow of classroom subject matter? In this project, we have designed several kinds of connections to assist teachers in finding not only the place where the new materials fit, but also the justification for fitting them and the ancillary resources that can contribute to their effectiveness. The connections we see are demonstrated here and in the charts on the following pages.

EARTH SYSTEMS EDUCATION

http://earthsys.ag.ohio.state.edu

Earth Systems Education is a program of curriculum restructure in which teachers take responsibility for critical evaluation of their science curriculum, including content, classroom processes, learner outcomes, and assessment, and strive to make changes that create a curriculum more responsive to human needs and future quality of life. Earth systems education is based on integration of traditional science disciplines for a more comprehensive understanding of the interactions of Earth subsystems: the hydrosphere, lithosphere, atmosphere, biosphere, and cryosphere.

Efforts are guided by a Framework of Seven Understandings (p. 7 and 179) developed by science teachers, science educators, and scientists to represent fundamental desired results of all of science education. Each activity in this set addresses a number of the Understandings and two or more Earth subsystems, and includes suggestions for extending learning.

The process of curriculum change is assisted by scientists and science educators through development of materials such as these. Additional materials available for Earth Systems Education include a resource guide for science curriculum restructure using Earth as a focus. The guide, titled *Science is a Study of Earth*, includes research background, teacher experiences, and samples of activities useful at elementary, middle, and high school levels. Another volume of activities is designed to help secondary science teachers address the complex issues of global change. *Activities for the Changing Earth System (ACES)* includes 20 interdisciplinary activities. These publications are available from the Earth Systems Education Program, c/o OSU School of Natural Resources, 2021 Coffey Road, Columbus, OH 43210.

Ohio Sea Grant has also produced regional information and activities about global change. *Great Lakes Instructional Materials for the Changing Earth System (GLIMCES)* includes classroom activities for secondary science, based on *Global Change in the Great Lakes Scenarios*. These can be ordered ($9.00 for both) from Ohio Sea Grant, 1314 Kinnear Road, Columbus, OH 43212-1194.

GREAT LAKES
ENVIRONMENTAL
ISSUES

		Earth Systems Understandings							Earth Subsystems				
		Beauty & Value	Stewardship	Scientific Process	Interactions	Change Through Time	Earth As Subsystem	Careers & Hobbies	Hydrosphere	Lithosphere	Cryosphere	Atmosphere	Biosphere
pg. #	Activities:	1	2	3	4	5	6	7	1	2	3	4	5
15	How big is a crowd?	X	X		X			X	X	X			X
19	Who owns the resources of the Great Lakes?		X					X	X	X		X	X
25	How (environmentally) insulting can we get?		X	X	X				X	X		X	X
29	How skillfully can you read science articles?	X	X	X	X				X	X			X
45	How much is one part per million?			X					X			X	X
49	Which fish can we eat?		X	X	X				X				X
57	How should the public health be protected?		X	X	X			X	X				X
71	How do toxins move through the food chain?				X				X				X
77	Toxic chemicals in the Great Lakes		X	X	X	X		X	X	X		X	X
87	Where do all the toxins go? (Internal View)		X	X	X			X	X	X		X	X
90	Where do all the toxins go? (External View)		X	X	X				X	X		X	X
99	Could we live without chlorine in the Great Lakes?		X	X	X			X	X	X	X	X	X
125	What can we learn about water quality in a river?		X	X	X				X				X
145	What happens when nutrients enter an estuary?		X	X	X				X	X			
155	What is the status of the Great Lakes Areas of Concern?	X	X	X	X	X		X	X	X		X	X
161	Where does oil pollution come from?		X	X					X				
167	How can an oil spill be cleaned up?		X	X					X			X	X
171	How does an oil spill affect living things?		X	X	X				X	X			X
177	What if...? (A Great Lakes investigation)		X	X	X				X				X

FRAMEWORK FOR EARTH SYSTEMS EDUCATION*

Understanding #1. Earth is unique, a planet of rare beauty and great value.

Understanding #2. Human activities, collective and individual, conscious and inadvertent, affect Earth systems.

Understanding #3. The development of scientific thinking and technology increases our ability to understand and utilize Earth and space.

Understanding #4. The Earth system is composed of the interacting subsystems of water, rock, ice, air, and life.

Understanding #5. Earth is more than 4 billion years old, and its subsystems are continually evolving.

Understanding #6. Earth is a small subsystem of a Solar system within the vast and ancient universe.

Understanding #7. There are many people with careers and interests that involve study of Earth's origin, processes, and evolution.

* complete Framework on page 179

NATIONAL SCIENCE EDUCATION STANDARDS

The activities in *Earth Systems – Education Activities for Great Lakes Schools* have connections to other national developments in science education. Numerous efforts have been under way in the 1990s to restructure science education in response to growing concerns that the historic "layer cake" (discipline-ordered) approach to science lacks relevance to students, prepares them poorly in life skills that demand science literacy, leaves U.S. students lagging on standardized international tests of science knowledge, and ignores or perhaps even perpetuates naive conceptions in science. The primary efforts to change these patterns have emerged from and been supported by national organizations in science and education.

The National Science Education Standards represent the National Academy of Science's attempt to develop guidelines for science curriculum restructure and systemic change in K-12 education. The National Standards include science content standards that express need for integration of disciplines, fewer topics in greater depth, and articulation across grade levels. They do more by providing guidelines for restructuring the teaching of science, the environment for science in schools, and assessment of science learning. The Standards emerged in 1995 as the most comprehensive and perhaps most esteemed of the restructure guidelines.

The accompanying matrix demonstrates the connections of *Earth Systems - Education Activities for Great Lakes Schools* to many of the National Science Education Standards. Standards preceded by an asterisk (*) are specifically addressed in this activity set.

Content standards, Grades 5-8

Science as inquiry
- * Abilities related to scientific inquiry
- * Understanding about scientific inquiry

Physical science
- * Properties and changes of properties in matter
- Motions and forces
- Transfer of energy

Life science
- * Populations and ecosystems
- Diversity and adaptations of organisms

Earth and space science
- Structure of the Earth system
- Earth's history

Science and technology
- * Understanding about science and technology

Science in personal and social perspectives
- * Populations, resources, and environments
- * Natural hazards
- * Risks and benefits
- * Science and technology in society

History and nature of science
- * Science as a human endeavor
- * Nature of science

Unifying concepts and processes
- * Order and organization
- * Evidence, models, and explanation
- * Change, constancy, and measurement
- * Evolution and equilibrium
- Form and function

BENCHMARKS FOR SCIENCE LITERACY

Project 2061 is supported by the American Association for the Advancement of Science (AAAS). Through its book *Science for All Americans*, this project identified science concepts that every high school graduate in the United States should know. Major contributions of this effort include the idea that "less is more," or that a curriculum dealing with fewer concepts in greater detail is preferred over the traditional vocabulary-laden mini-college courses common in U.S. secondary schools. Follow-up work through selected school districts has produced several models for implementing the curriculum changes implied by 2061 and has resulted in a set of Benchmarks for designing the course sequences and gauging the progress of students in science through their school careers.

Many of the Benchmarks are addressed through activities in this volume. They are too numerous to list here in their entirety, but the following Benchmarks are among those applicable to the activities.

Examples for grades 6-8 include:

- Scientists differ greatly in what phenomena they study and how they go about their work. Although there is no fixed set of steps that all scientists follow, scientific investigations usually involve the collection of relevant evidence, the use of logical reasoning, and the application of imagination in devising hypotheses and explanations to make sense of the collected evidence.
- New technologies increase some risks and decrease others. Some of the same technologies that have improved the length and quality of life for many people have also brought new risks.
- The environment may contain dangerous levels of substances that are harmful to human beings. Therefore, the good health of individuals requires monitoring the soil, air, and water, and taking steps to keep them safe.
- Most groups have formal or informal procedures for arbitrating disputes among their members.

For grades 9-12 this material addresses:

- The value of any given technology may be different for different groups of people and at different points in time.
- Human beings are part of the Earth's ecosystems. Human activities can, deliberately or inadvertently, alter the equilibrium in ecosystems.
- Benefits and costs of proposed choices include consequences that are long-term as well as short-term, and indirect as well as direct. The more remote the consequences of a personal or social decision, the harder it usually is to take them into account in considering alternatives. But benefits and costs may be difficult to estimate.
- Conflict between people or groups arises from competition over ideas, resources, power, and status. Social change, or the prospect of it, promotes conflict because social, economic, and political changes usually benefit some groups more than others. That, of course, is also true of the status quo.

Content standards, Grades 9-12

continued from page 8

Science as inquiry
* Abilities related to scientific inquiry
* Understanding about scientific inquiry

Physical science
* Chemical reactions
Forces and motions
Conservation of energy
Interactions of energy and matter

Life science
Biological evolution
* The interdependence of organisms

Earth and space science
Energy in the Earth system
Origin and evolution of the Earth system

Science and technology
* Understanding about science and technology

Science in personal and social perspectives
* Natural resources
* Environmental quality
* Natural and human-induced hazards
* Science and technology in local, national, and global challenges

History and nature of science
* Science as a human endeavor
* Nature of scientific knowledge
* Historical perspectives

Unifying concepts and processes
* Order and organization
* Evidence, models, and explanation
* Change, constancy, and measurement
* Evolution and equilibrium
Form and function

Other Connections

NOAA Global Change Education Program, U.S. Department of Commerce,
1100 Wayne Ave., Rm. 1210, Silver Spring, MD 20910-5603
(301)427-2089, http://www.noaa.gov/

Great Lakes Environmental Research Laboratory (GLERC) conducts environmental research with an emphasis on the Great Lakes, including toxins in the Great Lakes, natural hazards, ecosystem interactions, hydrology, and effects related to global climate change.
2205 Commonwealth Blvd., Ann Arbor, MI 48105
(313)741-2244, http://www.glerl.noaa.gov/

Canadian Atmospheric Environment Service
Environment Canada, 4905 Dufferin Street, Downsview, Ontario, Canada M3H 5T4

International Joint Commission (IJC) is an appointed commission of representatives from U.S. and Canada who act as advisors of management activities of the Great Lakes and rivers along the border between countries. The IJC incorporates public input and efforts of research, environmental, government, and business interests in their ongoing efforts. Main office: 100 Ouellette Avenue, Windsor, ON N9A 6T3.
(519)256-7821; Detroit Office: P.O. Box 32869, Detroit, MI 48232.
(313)226-2170, http://www.great-lakes.net:2200/partners/IJC/ijchome.html

Great Lakes Commission is an interstate commission of the eight Great Lakes states established in 1955 to "promote the orderly, integrated and comprehensive development, use and conservation of the water resources of the Great Lakes Basin."
The Argus II Building, 400 Fourth St., Ann Arbor, MI 48103
(313)665-9135, http://www.glc.org/

Great Lakes Information Management Resource (GLIMR) is an index of Environment Canada's Great Lakes programs, publications, and databases.
http://www.cciw.ca/glimr/intro.html

Great Lakes Information Network (GLIN) is a great place to start exploring the Great Lakes on the Internet.
http://www.great-lakes.net/

National Sea Grant College Program – Great Lakes Network
http://www.mdsg.umd.edu/NSGO/index.html (One web site links all Sea Grant programs.)
Illinois/Indiana Sea Grant Program, 1206 S. Fourth St., 104 Huff Hall, Champaign, IL 61820, (217)333-1824
Michigan Sea Grant College Program, 2200 Bonisteel Blvd., Ann Arbor, MI 48109, (313)763-1437
Minnesota Sea Grant College Program, 1518 Cleveland Ave., N., Rm 302, St. Paul, MN 55108, (612)625-2765
New York Sea Grant Institute, State Univ. of NY, Nassau Hall, Stony Brook, NY 11794-5000, (516)632-6905
Ohio Sea Grant College Program, 1314 Kinnear Rd., Columbus, OH 43212-1194, (614)292-8949
Wisconsin Sea Grant, 1800 University Ave., Madison, WI 53705-4094, (608)262-0644

Cooperative Institute for Limnology and Ecosystems Research (CILER).
Its research focuses on climate and large-lake dynamics, coastal and near shore processes, and large lake ecosystem structure and function. The institute is comprised of the University of Michigan, Michigan State University, and GLERL.
CILER, University of Michigan, Ann Arbor, MI 48109
http://www.glerl.noaa.gov/ciler/ciler.html

INTERNET SITES OF GENERAL INTEREST

National Climatic Data Center, http://www.ncdc.noaa.gov
U.S. Army Corps of Engineers, Detroit District, http://sparky.nce.usace.army.mil
Sea Grant Network, http://h2o.seagrant.wisc.edu/greatlakes/glnetwork/glnetwork.html
Canadian Great Lakes Information Management Resource, http://www.cciw.ca/glimr/intro.html
NOAA Home Page, http://www.noaa.gov/
The Ohio State University Atmospheric Science Program, http://asp1.sbs.ohio-state.edu/
Great Lakes Forecasting System, http://superior.eng.ohio-state.edu/. Lake Erie maps updated every 6 hours.
Ohio Sea Grant, http://www-ohiosg.osc.edu/OhioSeagrant
Eisenhower National Clearinghouse, teacher resources for mathematics and science, http://www.enc.org
Great Lakes Human Health Effects Research Program, http://atsdr1.atsdr.cdc.gov:8080/grtlakes.html
ATSDR's ToxFAQs, Polychlorinated Biphenyls (PCBs), http://atsdr1.atsdr.cdc.gov:8080/tfacts17.html
The Right to Know Network, http://rtknet.org/
U.S.E.P.A. Oil Spill Program, http://www.epa.gov/superfnd/oerr/er/oilspill/oilhome.htm
Try a search using the name, if the address has changed.

PUBLICATIONS AND OTHER MATERIALS

Fortner, R.W., Project Director; A. Lewandowski and Richard Meyer, Editors, 1996. *Great Lakes Solution Seeker* (CD-ROM). Columbus: Ohio Sea Grant Education Program, Ohio State University.

Fortner, Rosanne W., Project Director. Heidi Miller and Amy Sheaffer, Editors. 1995. *Great Lakes Instructional Material for the Changing Earth System.* Columbus, OH: Ohio Sea Grant Education Program, The Ohio State University. This set of activities explores the potential impacts of global climate change on various sectors of the Great Lakes. Concepts are organized for cooperative learning strategies.

Fortner, R.W. and V.J. Mayer. 1993. *The Great Lake Erie. A Reference Text for Educators and Communicators.* Columbus: Ohio Sea Grant. This is the source of information used in most of the activities. Chapters are written by experts in Great Lakes topics, and readings from the book can serve as the content base for additional instruction.

Mayer, V.J. and R.W. Fortner, 1995. *Science is a Study of Earth: A resource guide for science curriculum restructure.* Columbus, OH: Earth Systems Education Program, The Ohio State University. Ideas on effective ways to improve science teaching and learning, assess progress, do cooperative learning, conduct workshops, etc. Sample activities for grades K-HS.

State of the Great Lakes 1995. Prepared by Environment Canada and U.S. Environmental Protection Agency. Request copies from: Environment Canada, 867 Lakeshore Road, Burlington, Ontario, Canada L7R 4A6 or Environmental Protection Agency, Great Lakes National Program Office, 77 West Jackson Blvd., Chicago, IL 60604 U.S.A.

The Great Lakes. An environmental atlas and resource book. 1995. Jointly produced by the Government of Canada and U.S. EPA, 3rd edition. Copies are available from the Great Lakes National Program Office, U.S. EPA, 77 W. Jackson Blvd., Chicago, IL 60604.

The Great Lakes Forecasting System, Department of Civil Engineering, The Ohio State University, with support from GLERL, NOAA. This online system makes predictions of physical variables of the Great Lakes and gives maps of existing conditions on Lake Erie, updated every 6 hours.
World Wide Web address – http://superior.eng.ohio-state.edu/

OTHER RESOURCES

Brown, Shirley, David Crosby, and Dan Jax. *Earth Systems Science Activities*. 1995. Columbus, OH: Bexley Middle School. Activities for grades 6-12 using an Earth Systems Education Framework approach. Funding provided by Ohio Environmental Protection Agency (Ohio EPA) and Ohio Environmental Education Fund (OEEF). Available from Bexley Middle School (publisher), 300 S. Cassingham Road Bexley, OH 43209. Phone: (614)237-4277; FAX: (614)231-8448

Glassner, Kathe, et al. *Making RAPs Happen. Financing and Managing Cleanups at Great Lakes Areas of Concern.* 1991. The Center for the Great Lakes. Request copies from: The Center for the Great Lakes, Information Service, 35 East Wacker Drive, Suite 1870, Chicago, IL 60601

Mitchell, Mark K., and William B. Stapp. 1992. *Field Manual for Water Quality Monitoring. An Environmental Education Porgram for Schools*, 6th edition, 7th printing. Dexter, Michigan: Thomson-Shore, Inc. 240 pp.

Review and Evaluation of the Great Lakes RAP Remedial Action Plan Program 1991. June 1991. Great Lakes Water Quality Board Report to the Internation Joint Commission, U.S. and Canada.

U.S. E.P.A. Wetlands Hotline: 1-800-832-7828. Publication list and other resources are available.

U.S. E.P.A. *The EPA Great Waters Program: An Introduction to the Issues and the Ecosystems*. EPA-453/B-94/030. April 1994. Durham, NC: Office of Air Quality Planning and Standards.

WOW! The wonders of wetlands, produced through a partnership between Environmental Concern, Inc. and The Watercourse. 1995. St. Michaels, MD: Environmental Concern, Inc.; Bozeman, MT: The Watercourse. Hands-on learning activities about wetlands for grades K-12. Available for sale by:
The Watercourse
201 Culbertson Hall Montana State University
Bozeman, MT 59717-57
Phone: (406)994-5392; FAX: (406)994-1919
Also available from Environmental Concern Inc., P.O. Box P, St. Michaels, MD 21663-0480.

Arts and Literature of the Great Lakes

Many scientists report that their interest in science is at least in part related to their feelings of wonder at the Earth's beauty. As is stated in Earth Systems Understanding #1, "The beauty and value of Earth are expressed by and for people of all cultures through literature and the arts." The developers of ES-EAGLS encourage teachers to use art, music, and literature in teaching. Not only does this address diverse learning styles and stimulate creativity, it also helps students find meaning behind what may otherwise appear to be topics irrelevant to their lives.

Much support is available for teachers to include the arts in teaching science. Listed below are some of the resources the authors have found most valuable. Your school's librarian and music teacher may know of other resources that relate to your specific region or Great Lake. Consult local units of the Great Lakes Historical Society and merchants in resort areas of the lakes as well.

SELECTED MUSIC RESOURCES

Lee Murdock's Great Lakes folk songs are popular in auditorium programs, private performances, and on cassettes. *Cold Winds* and *Freshwater Highway* are our favorite albums. Depot Recordings, P.O. Box 11, Kaneville, IL 60144 (phone 708/557-2742)

Paddle-to-the-Sea. 1990. Narrated, composed and performed by Liona Boyd. Winnipeg, Canada: Oak Street Music Inc. Based on the book *Paddle-to-the-Sea* by Holling C. Holling. The original book can be an additional reference for Great Lakes activities, and a supplemental guide is available from Ohio Sea Grant, The Ohio State University.

Pat Dailey is a country rock singer from Bay Village, Ohio. His albums are a mix of bar-room humor and serious songs of the Great Lakes. We use his "Great Lakes Song" and others from the *Freshwater* and *Shore Lines* collections most often. Albums are available from Olympia Records, P.O. Box 40063, Bay Village, OH 44140.

"Privateer," a Celtic folk duo from the Chicago area that sings traditional Great Lakes songs and original material related to the lakes. Sextant Music, 6342 W. Belmont, Chicago, Il 60634 (312/775-1257)

"Banana Slug String Band" has excellent songs about the Earth system for younger students. Contact them at BSSB, P.O. Box 2262, Santa Cruz, CA 95063.

The Sierra Club Survival Songbook, collected and edited by Jim Morse and Nancy Mathews, introduction by Pete Seeger, illustrated by Jos. A. Smith. San Francisco: Sierra Club, 1971.

SELECTED ART AND POETRY RESOURCES

Earth Songs by Myra Cohn Livingston, Poet and Leonard Everett Fisher, Painter. 1986. New York: Holiday House, Inc.

Hangdog Reef. Poems Sailing the Great Lakes. This is the only volume we have found specific to Great Lakes topics. Please let us know if you find others!

In a Grain of Sand, by Andreas Feininger. 1986. San Francisco: Sierra Club Books. Several photographs portray the beauty of natural processes.

The Canadian McMichael Collection from the McMichael Galleries in Toronto includes the best collection of the Canadian Group of Seven landscape artists.

Great Art for Great Lakes is a program of the province of Ontario, through Environment Canada.. Each year since 1993, Ontario students in grades 5-8 are given the opportunity to express their interpretations of the greatness of the lakes through a visual arts contest. By visiting the Internet site at http://www.cciw.ca/cgi-bin/ you can see the winning art from the past years.

Great Art for
Great Lakes
Les jeunes artistes
des Grands Lacs

How big is a crowd?

The Great Lakes and the surrounding land provide many resources for the people who live in the area. Water for drinking and industry, fish for food, minerals, and other resources are abundant. However, people change the landscape. They create wastes and add chemicals to the environment when they use resources, and these can be harmful. When many people are concentrated in one area, they may compete for resources. In addition, the wastes these people generate tend to concentrate in the area immediately around them and may cause pollution problems.

Unlike other activities in this volume, this is written to and conducted by the teacher.

OBJECTIVES

When students have completed this activity, they will be able to:

- Compare the relative sizes of the five Great Lakes and their human populations.
- Describe some of the problems that arise when many people depend on a limited resource.

PRE-LAB

1. Cut lengths of string and tie the ends together to make loops proportional to the areas of the five Great Lakes. Suggested lengths in meters are given for groups of less than 30 and more than 30 participants.

String Lengths Needed

	Class Size	
	less than 30	**greater than 30**
Lake Superior	8.5m	11.0m
Lake Michigan	6.0m	7.5m
Lake Huron	6.0m	7.5m
Lake Erie	2.5m	3.0m
Lake Ontario	2.0m	2.5m

2. Decide how many students will be "populating" each of the lakes. Use the chart on the next page to assign numbers of students to represent the relative numbers of people living around each lake. Numbers are given for both United States and Canadian residents (U.S./Canada). Remember that Lake Michigan is the only Great Lake that shares no border with Canada.

Materials

- Ball of string.
- Masking tape.
- Area, Population, and Fish Production tables.
- 100 (minimum) wrapped candies or peanuts in shells.
- 5 paper bags.

Earth Systems Understandings

This activity focuses on ESU 1 (beauty and value), 2 (stewardship), 4 (interactions), and 7 (careers and hobbies).

Source

This activity originally came from *Supplemental Curriculum Activities to Accompany Holling's Paddle-to-the-Sea* by Marcia L. Seager, Rosanne W. Fortner, and Timothy A. Taylor.

Note

You may want to invite another class to share in this activity, especially if your class has less than 20 people in it. Larger numbers of participants better illustrate the differing concentrations in population throughout the Great Lakes region.

Number of People

U.S. / Canada

Total participants	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**
Lake Superior	0/0	0/0	0/0	1/0	1/0	1/0	1/0	1/0
Lake Huron	1/0	1/1	1/1	1/1	1/1	2/1	2/1	2/1
Lake Ontario	1/2	1/3	2/3	2/4	2/4	2/5	3/5	3/6
Lake Erie	4/1	6/1	8/1	8/2	11/2	12/2	13/3	15/3
Lake Michigan	6/0	7/0	9/0	11/0	13/0	15/0	17/0	19/0

3. Divide wrapped candies or peanuts in shells into groups representing the proportional number of fish caught annually in each of the Great Lakes. You will need at least 100 candies or peanuts. One candy or peanut represents approximately 50 tons of fish. Label the five bags with the names of the five lakes and use the table below to put the correct number of "fish" in each bag. (For groups of less than 25 students, you may want to halve these numbers.)

Proportional Number of Fish Caught

Lake Superior	8
Lake Michigan	35
Lake Huron	5
Lake Erie	50
Lake Ontario	2

PROCEDURE

1. Arrange the loops of string that represent the five Great Lakes into the approximate shapes of the Great Lakes. With masking tape, add a dividing line to each lake to show that each lake (except for Lake Michigan) has both a U.S. and Canadian side. Ask the students:
   - Which of the lakes has the largest area? Which has the smallest area?
   - Without using the chart as a reference, where would you guess that most people live?

2. Assign the appropriate numbers of participants to the U.S. and Canadian sides of each of the lakes. (An alternative is to assign participants to each lake without specifying a country. In this case you do not need the border.) Each participant should put one foot on the string "shore" of the lake.
   - Where are people closest together?
   - Did anyone have a hard time finding room to stand?
   - On which lake or lakes do you think the biggest cities are located?
   - Which lakes have the largest and smallest populations?
   - Are more people living near the eastern or the western lakes?
   - Are more people living near the U.S. or the Canadian shores?

International border line

3. Pass the appropriate bag of "fish" around each lake. Each person takes ONE piece of candy or peanut each time the bag is passed to him or her until the bag is empty. (If you have no one assigned to Lake Superior, set aside that bag and do not distribute those "fish" in the other lakes.)
   - Which lake had the most "fish"?
   - In which lake did people catch the most? Why do you think this is so?

4. People create waste when they use resources, and much of that waste is carried by water. Too much waste causes pollution problems. Open and eat your "fish." Put the wrappers or peanut shells on the floor inside the loop of string that is your lake.
   - In which lake is the waste most concentrated (greatest amount, closest together)?
   - Remember that the water from each lake flows into the lake downstream (in this case, to the east) of it. Which lake or lakes do you think might have the worst pollution problems? Why do you think so?

5. Have students use the Great Lakes Atlas and/or the Great Lakes Information Network (GLIN) online to find out more about the uses people make of the Great Lakes, the relative sizes of the lakes, and the human impacts on the region. Start the searches at http://www.great-lakes.net.

6. Clean up and discuss the activity together.

DISCUSSION QUESTIONS

1. What relationships have you seen between population, resources, and waste?
2. What could you have done to make sure ALL participants got an equal number of "fish?" (Sell or trade for other resources or services, for example.)
3. How do you think the amount of pollution in the Great Lakes could be reduced?
4. How could you reduce the amount of waste you produce?

EXTENSIONS

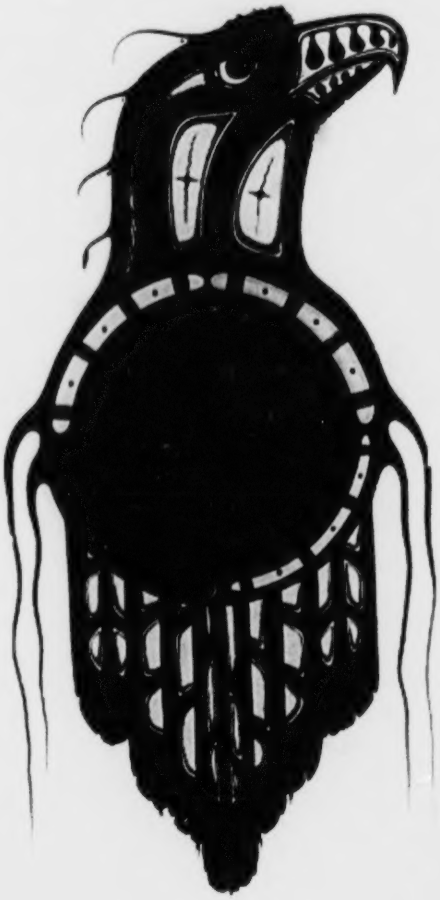
Play math games with Great Lakes areas and populations. For example, find out how many times Lake Erie could fit in one Lake Superior, how many people per square meter there are in each lake's watershed, and so on.

Organize a Clean Campaign to learn more about recycling. Find out what lakeshore communities do with wastes from fishing. Use the Internet to find out what the pollution levels are in each of the Great Lakes.

Who owns the resources of the Great Lakes?

The Great Lakes are a valuable resource for many people. This section examines the cooperation and conflict that exists among the groups who share the Great Lakes as a common resource. Several organizations have been established to help various interested parties work together. The International Joint Commission, (IJC) is one of the primary groups. It was formed in 1909 by Canada and the United States to assist in resolving transboundary water pollution issues: water quantity, water quality, and water allocation and use. In 1972, Canada and the United States signed the Great Lakes Water Quality Agreement as a first step toward the protection and clean-up of the Great Lakes. The role of the Native American community in the health of the Great Lakes basin is also very important and is often surrounded with controversy. In Part 1 of this activity, Native American uses of the Great Lakes region resources will be investigated.

Part 2 of this activity will help you understand what is meant by the term "tragedy of the commons," or how resources can become abused when they are owned by everyone.



The eagle is a cultural symbol universally recognized by Native American people. Not only does the symbol depict the Great Lakes basin area, but it also symbolizes some of the cultural principles of the native peoples of the Great Lakes.

Surrounding the center medicine wheel are the *four colors of human beings (red, yellow, black, and white).* This acknowledges respect for all people, who are all part of Creation. The seven eagle feathers represent both a prophesy and a philosophy for decision-making. The time of renewal and reflourishing of the Native American tradition is know as *the lighting of the Seventh Fire.* The current and seventh generation from the time when this prophecy originated has symbolically lit the *Seventh Fire.* The seven feathers also symbolize a traditional decision-making process which decrees that any course of action taken must not negatively impact all relations (both human and non-human) seven generations into the future.

The Medicine Wheel represents the holistic approach to health, which embodies the physical, mental, emotional, and spiritual well-being of individuals and communities. The four points on the wheel also represent the cyclical process for change. A problem is identified in the *East,* feelings regarding the problem are expressed in the *South,* an understanding of the problem is achieved in the *West,* and positive actions are taken to bring change in the *North.*

Source of symbol and description of symbol: Assembly of First Nations

Materials

Procedure Part 1

- Materials for a display - posterboard, markers, tape, etc.
- Access to resource materials about Native Americans in the Great Lakes region.

Procedure Part 2

- Bowl or plate.
- Items to represent resources (enough for everyone in the class to have at least four). Can be candy (marshmallows, chocolate kisses, jelly beans) or an item such as styrofoam "peanuts."

Earth Systems Understandings

This activity focuses on ESU 7 (careers and hobbies) and 2 (stewardship).

Suggestion

Invite a Native American leader in your region to speak to the class. Prepare questions ahead of time and also allow time for a presentation by your guest. Ask your visitor to comment on prevalent Native American issues today.

OBJECTIVES

When you have completed this investigation you should be able to:

1. Describe the need for international cooperation in the protection of resources.
2. Describe many of the ways that Native Americans use and rely on the Great Lakes basin.
3. Describe the conflict regarding Native American rights and responsibilities to the Great Lakes.

PROCEDURE: PART 1

Conflicts often arise because people disagree on how resources should be used and who should get to use them. For instance, the history between Native Americans and others living around the Great Lakes includes many disagreements as to the hunting and fishing rights of the various parties. Legally, Native Americans do not have to follow the same hunting and fishing laws as other citizens because they never gave up those rights based on treaties made with the U.S. government. Several activist groups have developed which either support or lobby against the "special" rights of Native Americans in the Great Lakes region. The groups *Honor Our Neighbors Origins and Rights (HONOR)* and *Citizens Equal Rights Alliance (CERA)* are examples of these groups.

1. Your class will conduct research to learn about traditional and current Native American uses of Great Lakes regional resources, (wild rice culture, fishing, native songs/dances, bird uses, water uses, etc.). You may also decide to include important Native American issues, such as health or hunting rights, in your investigation of Great Lakes Native Americans.

2. As a class, decide which uses/issues are the most significant and should be included in a Native American display.

3. The class is divided into groups. Each group is responsible for developing a display about one or more of the significant uses of Great Lakes resources or an important issue.

4. The class will present a Native American fair to display the ideas for others to see.

PROCEDURE: PART 2

1. The class should be divided into two equal sized groups (Group 1 will be the first generation and Group 2, the second generation. Group 1 can then become the third generation, and so on.)

2. Group 1 sits on the floor in a circle with a container in the middle. Group 2 should watch and listen but not offer input.

3. Read the following instructions and conduct Round 1:
   The group sitting in a circle represents all of the people presently living in the Great Lakes region. All of the resources of the area (fish, clean air, clean water, timber, minerals, recreational areas, etc.) will be in the container.

   Round 1 will last only 10 seconds. During that time each member of the first generation may take as many resources as they want, because the resources belong to everyone. The more resources each person has, the more "wealth" he or she has. One resource piece represents a frugal life-style, two pieces equal a modest but comfortable life-style, three pieces represent a very comfortable life-style, and four or more pieces represent extreme wealth.

   Any resources that are left in the bowl after the 10 seconds will be doubled, and the next generation (the group watching) will get a turn. For instance, if there are 10 pieces left, an additional 10 will be added for the next round. This is done because many resources are renewable. Fish, for instance, will spawn if they are not all caught and there will be a renewed supply of fish the following year. If all the fish are caught, however, they become extinct and do not reproduce.

4. Following Round 1, Group 2 sits in a circle around the container, and follows the above directions while the first generation watches.

5. Discuss the following questions.
   A. What is meant by the term "tragedy of the commons"?
   B. Did you discover anything about human nature while playing this game? (greed, sharing)
   C. Is more always better?
   D. What resources can you think of that belong to everyone and have the potential of being abused?

Teacher's Notes

You may create an atmosphere that will encourage students to be competitive and greedy. This will clearly demonstrate what can happen to resources without effective cooperation and planning.

To start Round 1, put enough candy in the bowl for every member of the first group to get four pieces (if they were to share equitably).

Theoretically, if the groups are the same size and everyone always takes only two resource units, the game can continue for an infinite number of generations, because the "pot" will always be replenished to the original level. You may want to explain this to the students after they have completed a few rounds to encourage them not to grab as much as they can – they will realize that they will ultimately get more resources if they do not initially take as many as they can get.

> ***"Today the demand for fish has greatly outstripped its supply, and non-Indians deeply resent Indian treaty rights. Indians frequently have had to rely on federal courts to enforce these rights."***
>
> *U.S. Supreme Court opinion*
> *December 5, 1979*

Hints for Question

5D. Students may want to discuss how the atmosphere and oceans act as common resources and the potential impact of one's country's use of the resources on another nation's available supply. Regional wildlife are often shared resources, such as game species and migratory waterfowl.

The following is an excerpt regarding a current situation involving tribal fishing:

Court Sets Great Lakes Tribal Fishing Zones

A federal court finding in a Great Lakes salmon dispute between the state of Michigan and various tribal entities provides a foundation for future negotiations and resolution according to Department of Natural Resources Director . . . (It) set interim tribal salmon fishing zones in Lake Michigan and Huron for 1996, and also outline specific criteria for fishing activity in those zones between August 1 and October 15.

Grand Traverse Bay in Lake Michigan has been at the center of the dispute, and much of (the) finding addresses a 3.5 mile stretch involving one species of fish and one tribal fisher. The order designates the boundaries of the Grand Traverse Bay zone and authorizes the Grand Traverse Band of Ottawa and Chippewa Indians to issue a single license to target fish for salmon under a set of narrowly defined conditions. Restrictions on the Grand Traverse Bay license and penalties if the terms are violated . . include:

- Any net used to target fish for salmon is restricted to between 600 feet and 900 feet;
- The net must have 7.5 inch mesh or greater stretch measure;
- The top float line must be submerged at least eight feet below the surface until September 30;
- From August 19 to August 24, only one net is permitted, while two nets will be permitted during the following week. The number of nets permitted after September 1 will be determined after an evaluation by the Technical Fisheries Review Committee and the Law Enforcement Committee, which consist of representatives from state, tribal, and federal governments.

The order directs that all fish taken under the permit must be landed at the Grand Traverse Band's biological station for data collection, monitoring and inspection by the two committees. Both groups then will submit periodic progress reports to the court.

(The following is a quote from the DNR director): "While we aren't completely satisfied with the order, we recognize it as an honest attempt by the court to provide a solid basis for resolving our differences in 1997 and beyond regarding fair and equitable distribution of fish stocks in the Great Lakes."

The order states that target fishing for salmon by tribal commercial fishers is limited to waters within one mile from shore and delineated by the following landmarks:

Lake Michigan

- Grand Traverse Bay zone: westerly of a line extending from Omena Point Light house south to the Stoney Point Light house and in accordance with the Chippewa-Ottawa Treaty Fishing regulations, no fishing within a half-mile radius of any river or creek mouth.

(Source: Michigan Department of Natural Resources, 1996).

QUESTIONS

1. Does the court order seem fair? According to the article, is this a final decision or a starting point for fishing management?
2. Would Native American interests regard this decision favorably? Would non-native fishing interests? What additional information, if any, do you need to answer the question?
3. How will the court order be implemented? What follow-up steps are being taken?

EXTENSION

Do research on the history of treaties made between the U.S. (or Canada) and Native Americans of the Great Lakes region. Based on your findings, decide what you think is a fair policy as far as hunting and gathering rights of Native Americans.

SUGGESTED RESOURCES

Great Lakes Indian Fish & Wildlife Commission (GLIFWC) has numerous publications on Native American uses of resources. A list of their publications can be provided by contacting:

GLIFWC
Public Information Office
P.O. Box 9
Odanah, WI 54861
Phone (715) 682-4427 or (715) 682-6619
Fax (715) 682-9294

The Environmental Protection Agency and various tribes have initiated a plan to identify and prioritize tribal environmental needs for 1995-1997. Information is available from:

EPA-Great Lakes National Program Office Tribal Liaison.
Phone: (312) 886-6942.

Wedll, Don, Fim Pence, Marc Slonim and Ferdinand Martineau. 1995. *A Guide to Understanding Chippewa Treaty Rights*. Minnesota Edition. Distributed by Great Lakes Indian Fish and Wildlife Commission.

Internet Connections

Index of Native American Resources on the Internet
http://hanksville.phast.umass.edu/misc/NAresources.html

Native American Technology and Arts
http://www.lib.uconn.edu/ArchNet/Topical/Ethno/NativeTech/NativeTech.html

Native Americans and the Environment
http://www.ecsu.ctstateu.edu:80/depts/edu/bookmarks/native.html

Native American Literature Online
http://web.maxwell.syr.edu/nativeweb/natlit/NAlit.html

> ***The privilege of hunting, fishing, and gathering the wild rice upon the lands, the rivers and the lakes included in the territory ceded, is guaranteed to the Indians...***
>
> *-Treaty of 1837*

How (environmentally) insulting can we get?

Everything that we do impacts the world around us in some way. What are some examples that you can think of? One of the challenges of science is to come up with ways of measuring how much impact we are having. Is that impact bad, good, or not as bad as some other activity's impact? How would you go about trying to measure the impact of certain activities that you take part in each day on the world around you?

In this activity you will be taking part in a survey method to develop a way of measuring impact so that you can compare activities and decide what is more or less insulting to the environment.

OBJECTIVES

Upon completion of this activity, you will have:

- Collected and analyzed data.
- Quantified the environmental impact of one activity compared to another.

PROCEDURE

1. You will be collecting data in this activity and entering it into a spreadsheet or formula to come up with a number that will represent the **EIF** - *Environmental Insult Factor* for some activity/parameter. The formula we will be using is: **EIF = (bad EI - good EI) ÷ total EI** {EI=Environmental Impact}. For this to work, we must find some environmental impacts that we can judge as either good or bad.

   For example, at a given intersection we might compare the number of cars that have one passenger to those with more than one passenger and say that cars with multiple passengers represent less impact compared to single-passenger cars. What are some other examples that could be compared? Would doing the counting/survey at different times of the day make a difference? What else might need to be taken into account?

2. Plug some fictitious numbers into the formula to determine what happens to the EIF. When the EIF is large, does that indicate a good or bad situation? What type of EIF do you want, large or small?

Source

Modified from an activity developed by Robert Hellstrom, The Ohio State University. Environmental insult equation developed by Paul J. Kinder, The Ohio State University. Modified by Rick Meyer, The Ohio State University.

Earth Systems Understandings

This activity focuses on ESU 2 (stewardship), 3 (scientific process), and 4 (interactions).

Materials

- Handout, graph paper, calculator.
- Optional – Access to a computer with a spreadsheet such as Excel for computer graphing.

Teacher's Note

This activity has been designed for grades 7-12. With modification it could be used at other levels.

Possible Answers

2. Students may discover that negative answers represent a good situation; for example: (5 bad EI - 10 good EI) ÷ 15 total EI = -1/3, whereas (10 bad EI - 5 good EI) ÷ 15 total EI = +1/3. A negative number shows less impact, and a positive number more impact.

Answers

Answers will vary depending on the data used.

3. Some possible sources of data to use in the classroom without going into the field to collect data are: toxic releases by state, number of cars per state, water consumption, wetland percentage, money spent on pollution, and money spent on recreation. You might look in an almanac for this information or use the Internet as your source. The Great Lakes Atlas is a good source of data.

Teacher's Notes

Start with a whole-class activity. Go through the activity as a group and explain any questions. You may want to start out by collecting some data such as the car data or some other factor that you can do close to school, and then go through the activity using those data to plug into formulas as an example. Once students understand the formulas and the concept of Environmental Insult Factor, divide the class into groups to discuss what activity they would like to study using the EIF. Have students fill in procedures 4 and 5 and discuss them with you before they start their study. You should consider whether they will be getting data in number format and determine that the study will be safe (not put the students in danger). Students then should collect their data, record them and graph them. Each group can then report back to the class on what was studied, why, and what their results were.

3. Discuss as a group what activity (environmental impact) you want to study. Decide what the good factor is and the bad factor so that every one understands how to judge the activity. (Consider safety in your selection, and get your selection approved by your instructor before beginning.) What activity are you going to study using the EIF?

4. Write out your formula. For example: EIF of passengers = (singlecar - multiplecar) ÷ totalcar; singlecar = cars with one passenger; multiplecar = cars with more than one passenger; totalcar = total cars counted.

Your formula: ______________________________

Your definitions: ______________________________

____

____

5. What impact are you trying to quantify (use numbers to compare) in your equation? (In the above example, the objective is to quantify the impact of number of passengers in cars on air pollution. More passengers means that less pollution is produced per person.)

6. Collect some sample data to make sure that every one understands and that it will fit into the formula. Determine how the data will be collected (when, where, how long, . . .).

7. Collect data on the activity that your group decided to study. Collect the data from several locations or at different times of the day. Organize the data into a data table and also graph the data so that you can compare what you collected. If you have access to a computer with spreadsheet software, you can use it to produce your tables and graphs.

8. Two factors that will affect the actual environmental impact are population of an area and the size of the area that is being studied. Higher population density will often contribute to environmental degradation. So if it is possible, you can multiply the EIF by the population density that transfers the responsibility of the environmental insult onto the inhabitants of the area. Population density is calculated by taking the population and dividing by the area. This will change the formulas to the following:

EIF = (bad EI - good EI) ÷ total EI x Population ÷ Area

EIF of passengers =
(singlecar-multiplecar) ÷ totalcar x Pop ÷ Area

How would population density affect your study? Compare the EIF with a low-population density and a high population density.

9. Can you compare your EIF directly to the EIF that other groups collected for other activities?

10. What might cause the EIF that you came up with in your study to change? What could you as an individual do to help improve the Environmental Insult Factor where you live?

EXTENSIONS

1. Use a computer to help in the analysis of the data you collected.

2. Collect population data for your area by contacting your local government or going online and accessing census data (use the Internet site http://www.census.gov).

3. Collect EIF data before and after the completion of a public service project to determine the effectiveness of the project.

RESOURCES

Statistical record of the environment. Darnay, Arsen. 1992. Gale Research. Detroit, MI.

Green Index: A state-by-state guide to the nation's environmental health. 1991. Island Press. Washington, DC.

The Great Lakes: An Environmental Atlas and Resource Book. 1995. Government of Canada and the United States Environmental Protection Agency. Great Lakes National Program Office, Chicago, IL.

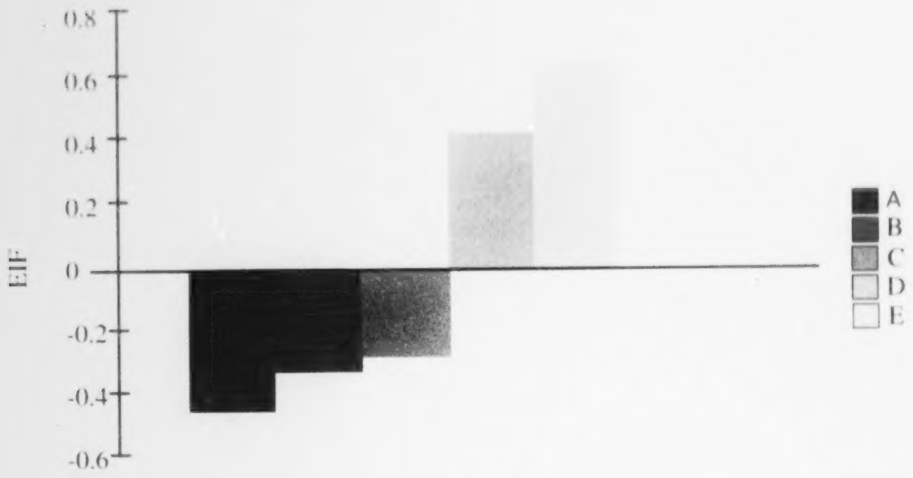
Note

9. One EIF number cannot be compared directly to the EIF of another activity. The activity must be the same for a direct comparison. The EIF of a variety of activities for a particular area might be compared over time to see if the environment is being more or less severely impacted by human activity.

Sample data for a comparison of single-passenger vehicles to multi-passenger vehicles arranged in a spreadsheet format and in graph format.

Location	EIF	1 / car	2+ /car	Total cars
A	-0.43	10	25	35
B	-0.33	15	30	45
C	-0.27	20	35	55
D	0.43	25	10	35
E	0.67	25	5	30

Traffic Insult vs. Location



How skillfully can you read science articles?

Do you believe everything you hear or read? Certainly not. You probably have some sources of information that you trust more than others – the television news reporter, the front page headlines, or maybe a teacher who seems to know a great deal about a lot of things. You feel that what these sources report must be true. Whenever you read or hear something, you react to it in some way. Whether you are aware of it or not, you make a decision about accepting or rejecting the information. You may also decide, based on how important or interesting the information seems to be, whether to try to remember it.

Speakers and writers sometimes take advantage of people by trying to make them react in a certain way. By using certain words or tones of voice, they try to persuade us that what they are saying is true. While scare tactics are not really an approved method of getting people's attention, sometimes they can be very effective. In the late 1960s for example, WBBM-TV in Chicago aired a special called "Too Thick to Navigate, Too Thin to Cultivate," exposing Great Lakes pollution problems. NBC News followed with a special documentary on "Who Killed Lake Erie?" Lake Erie has always been a valuable resource for those living around it. Could we lose this resource one day because of pollution?

This activity contains three articles. By analyzing them, you will study problems associated with water pollution in Lake Erie and develop strategies for reading science articles skillfully and critically.

OBJECTIVES

After completing this activity you should be able to:

- Recognize the main topic in a science article.
- Recognize the subtopics.
- Organize related information under each subtopic.

algae
PO4
DO
poison
SCIENCE
JR7 5-87

Materials

- A copy of the included articles and procedure for each student.

Earth Systems Understandings

This activity focuses on ESU 1 (beauty and value), 2 (stewardship), 3 (scientific process), and 4 (interactions).

Source

Modified from OEAGLS EP-8B, *Pollution in Lake Erie: An Introduction*, by Carole P. Basehore and Rosanne W. Fortner.

PROCEDURE

PART A: *SO LONG LAKE ERIE* (READING COMPREHENSION)

A. Read the article *So Long, Lake Erie* using the following tips to help you develop a strategy for reading.

1. The article discusses three major ideas. You can identify these ideas by picking out key terms in paragraphs 1, 6 and 9. Paragraph 1, for example, could be condensed into the main idea "People and Industries Killing Lake Erie." That gives you a clue about what to look for in the first section – HOW are people and industries killing the lake?

2. See if you can condense the first sentence of Paragraph 6 and all of Paragraph 9 so that you have the main ideas for the sections that follow those paragraphs.

3. Read the entire article with the ideas of each section in mind. Try to find explanations for and details about the key statements you have found.

B. When you finish reading and feel confident that you have grasped the major ideas, answer the following questions.

4. List 10 major sources of pollution for Lake Erie's waters.

5. The authors of the article, *So Long, Lake Erie,* noted that approximately 360 industrial companies discharge their wastes into the lake. From the article, identify the types of substances that make up industrial waste. You may use some of the same answers you found for question 1.

6. List six ways that pollution in Lake Erie has decreased the lake's value.

7. From your understanding of what you read in the article, describe the water of Lake Erie and the conditions of life within the lake.

Answers

A1. Paragraph 1 is used as an example, condensing it to say "People and Industries Killing Lake Erie." Paragraph 6 introduces the effects of pollutants on the lake. Paragraph 9 begins a section on what is being done about the problems.

4. 10 major sources of pollution include:
   - sewage
   - chemicals from agriculture, industry
   - soil from erosion
   - power plants (thermal pollution)
   - spoil from dredging
   - industries (toxic materials, oil, acids)
   - boat wastes
   - trash
   - radioactive materials
   - phosphates from fertilizers, detergents

5. Industrial wastes include acids, oil, cyanide, iron, phenol, toxic metals, and poisonous chemicals from pesticides, plastics, and chemical industries.

6. The lake's value had decreased in these ways: using up oxygen in the water, stimulating the growth of water plants, killing organisms, preventing sunlight from penetrating the water, causing the fishing industry to decline, and making people sick. Students may infer other effects or offer personal experiences that should be discussed as additional answers to this question.

7. Answers will vary based on student maturity and understanding of the materials. Be accepting and discuss all possibilities with the class.

C. The article mentioned that one of the major effects of pollution on Lake Erie was "eutrophication." To better understand eutrophication, read the next paragraph from the book *Water Wasteland*, by David Zwick and Marcy Benstock. Remember to first identify the general statement that will give you a clue as to what kind of information to expect in the reading.

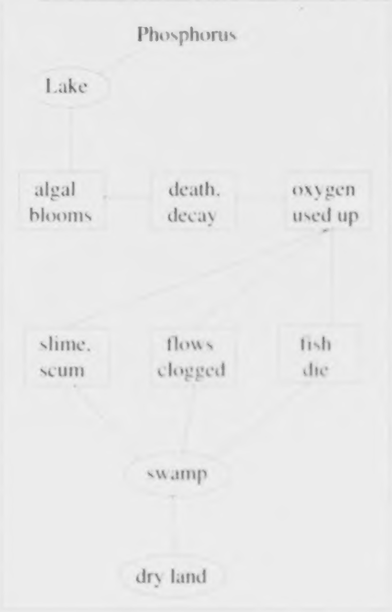
EXCERPT FROM WATER WASTELAND

"Phosphorus stimulates the growth of algae and aquatic weeds in fresh-water lakes and rivers. Sudden and massive algal growth (called blooms) appear in many American waterways in early spring and summer. They are ugly growths, but the problem is not solely aesthetic. These blooms age a body of water as they die and decay. Oxygen and other resources are exhausted in the oxidation of large amounts of dead organic matter. Slime and scum appear, flows are clogged, and the water is unable to support fish or other normal life forms. This natural aging process, by which lakes and rivers turn to swamps and then dry land over the course of centuries, is called eutrophication. When phosphorus and other nutrients for algal growth pour into our lakes and rivers from municipal and industrial wastewater and from urban and agricultural runoff, the natural aging process is speeded up, often many hundreds or thousands of times. Lakes and rivers "die" an early death from over-enrichment, overblooms, and what might be called overkill in the algal life cycle."

8. Using the information from this paragraph, construct a chart that shows the events, in order, that take place in eutrophication.

9. From the chart and the article, do you think that Lake Erie is dead? Explain your answer.

8. Eutrophication chart (may vary in form, but should include all major parts):



9. From the chart and the article, it appears that Lake Erie is living much too quickly but is not dead.

Teacher's Note

Encourage students to discuss the credentials of the authors of articles and whether or not people's backgrounds can add strength to or weaken their arguments.

Answers

10. 1970. The article was a part of the "alarmist" phase of environmental protection. People were actively pointing out how bad the conditions of the environment had become. NBC's "Who Killed Lake Erie" came in late 1969, for example. Conditions have improved greatly since then. Recognizing its mistakes, society has determined to correct many of its abuses to the environment.

11. The authors were mainly concerned citizens. Their professional training did not involve any preparation for serving as water pollution experts.

12. It appears that the article states facts. There are no words that indicate an opinion is being stated, like "it seems," "probably," and such. There are some parts of the article that have no basis in fact. For instance, radioactive materials have never been a problem in Lake Erie, and the number of nuclear power plants along the shore is not increasing. Since the article does not have a list of references at the end, it is impossible to discover where such ideas originated.

13. From paragraph 8 – "the attacks upon Lake Erie are now so strong and so unceasing that little hope remains for its survival." The article has evidence that points to this conclusion. There are glimmers of hope, as in paragraph 9, but they are quickly extinguished by pessimistic reports.

14. Yes. Some persuasive terms used are: disastrously, raw wastes, dangerous and filthy, a mob job, and so forth.

PART B: *SO LONG, LAKE ERIE* (CRITICAL READING)

In order to become a critical reader, one who can determine the truthfulness and possible value of what is read, you have to look carefully at every word of the writer. You should try to:

- Avoid quick judgments,
- Sort out arguments and
- Weigh evidence.

D. Answer the following questions:

10. When was it published? What was happening in this country at that time? Have conditions changed since then?

11. Who wrote the article? What qualifies the authors to write about the subject, i.e., what are their credentials that would make the article believable.

12. Does the article state opinions or facts? How did you decide?

13. What are the writers' conclusions? Does the article have evidence that supports the conclusion?

14. Does the article use words designed to persuade your thinking? If so, list three or four of these words or groups of words.

PART C: *LAKE ERIE* BY JAMES BARRY

E. Read the included article *Lake Erie* by James Barry and answer the following questions.

15. When was it published? What was happening in this country at that time? Have conditions changed since then?

16. Who wrote the article? What qualifies the author to write about the subject?

17. Does the article state opinions or facts? How did you decide?

18. What are the writer's conclusions? Does the article have evidence that supports the conclusion?

19. Does the article use words designed to persuade your thinking? If so, list three or four of these words or groups of words.

PART D : COMPARING AND UPDATING THE ARTICLES

Read the SOLEC 1995 article titled *Lake Erie* for a recent status report on the Lake. Compare it to the other articles.

F. Answer the following questions.

20. Does the information in *Lake Erie* by James Barry and the SOLEC article conflict with what the writers of *So Long, Lake Erie* had to say? How is the conflicting information presented?

21. In which information do you place more confidence? Why?

22. Summarize what you believe to be the present condition of Lake Erie.

23. One of the most valuable things you can do to become a skillful critical reader is to read widely from all kinds of books, magazines, and newspapers. Why?

Answers

15. The article *Lake Erie* is from a pamphlet prepared for the Ohio Environmental Protection Agency, March 1980. Students should investigate and discuss how the decade of the 1970s was different than the 1980s. They may want to do some additional research on the two time periods for comparison purposes.

16. James Barry is the writer of the article, and he is an author and photographer whose work deals with Great Lakes topics.

17. Answers will vary for questions 17-19. Discuss reasons for different answers.

Students can also read the September 1996 article in Audubon titled *Biography of a Lake* by Jon R. Luoma for a recent status report of Lake Erie. They can compare it to the articles included in the activity.

20. Yes. See the James Barry article. Barry is a respected writer on Great Lakes topics. The article is published as an official statement from the Ohio Environmental Protection Agency. Students should discuss differences between the articles.

21. Students should place more confidence in the Barry and SOLEC articles because of their recency and sponsorship by the Ohio Environmental Protection Agency and Environment Canada in the latter. Also, they are written in a less dramatic and more factual tone. Each is no less impressive in its message, but it is much more rational than the third article.

22. Answers will vary. The present condition of the lake has improved over the past and in the current decade, and continued improvement is expected, especially in phosphorus levels.

23. If the students had read only the first article, they would have a distorted impression of the Lake's condition. Only by exploring many views on a problem can a person build an informed opinion.

Answers

1. (Any four or five of the following should suffice.) Sewage, poisonous chemicals, soil, hot water, dredge spoil, industries, boat wastes, trash, radioactive materials, and phosphates pollute Lake Erie.
2. People have recognized the problems and taken steps to clean up the lake and prevent more damage to it. Sewage treatment plants have been improved, and laws now prevent the dumping of industrial wastes.
3. Lake Erie was never dead. The present condition of the lake is much improved. Beaches are open, fishing has improved, and phosphorus levels are down. Pollution input has slowed, but careful monitoring and continued concern are still needed.
4. Look for opinion words and persuasive language, determine who wrote the article and when, and examine the evidence for conclusions that are drawn.

Evaluation

This activity is not designed to teach facts about pollution, but rather to develop particular reading skills. We recommend that if specific evaluation is needed, you may use the actual answers students give, especially for the Review Questions.

For further investigation

Numerous references and activity guides about water pollution are available, and most biology and life science textbooks include sections related to this topic. Take care to select recent works for accurate presentation of the ideas.

If interest in water pollution is high, consider making a study of a nearby lake or stream during the course of a year. Basic physical and biological characteristics can be determined using standard equipment available in most school laboratories, and water analysis can become fairly sophisticated if you use a test kit such as those marketed by scientific companies.

REVIEW QUESTIONS

1. Historically, what are the major sources and types of pollution in Lake Erie?
2. How have some of these problems been handled?
3. Was Lake Erie dead? What is the present condition of the Lake?
4. List three things you should look for in something you read to tell if it is worth believing.

ADDITIONAL ARTICLES

For reviews of historic pollution and health incidents, consult the *Reader's Guide to Periodic Literature*. References you may be interested in for their photographs and general information are:

Colten, Craig E., and Peter N. Skinner. 1996. *The road to Love Canal: managing industrial waste before EPA*. 1st ed. Austin, TX: University of Austin Press. 217 pp.

Hoffman, Andrew J. "An uneasy rebirth at Love Canal." *Environment*. Vol. 37, No. 2. March 1995. pp. 4-9+ (13 pages).

Hoffman, Andrew J. "Love Canal lives." *E: The Environmental Magazine*. Vol. 5, No. 6. November 1994. pp. 19-22.

Holden, Constance. "Apple growers vs. CBS: TV wins." *Science*. Vol. 262, No. 5130. October 1, 1993. p. 35. (Note: Apple growers brought suit against CBS News' "60 Minutes" Alar report.)

"Love Canal polluters finally fined." *Environmental Action*. Vol. 28, No. 1-2. Spring 1996. p. 6.

Marshall, Eliot. "A is for Apple, Alar, and . . . Alarmist?" *Science*. Vol. 254, No. 5028. October 4, 1991. pp. 20-22.

Mitchell, J. G. "Corporate responsibility in Silver Bay" (Reserve mining company's pollution of Lake Superior). *Audubon* 77:46-61. March 1975.

Negin, Elliott. "The Alar 'scare' was for real." *Columbia Journalism Review*. Vol. 35, No. 3. September 1996. pp. 13-15.

Reisch, Marc. "Court rejects punitive damages for Love Canal." *Chemical and Engineering News*. Vol. 72, No. 13. March 28, 1994. p. 7.

Smith, W. E. and A. Smith. "Mercury pollution ravages a Japanese village." *Life* 72:74-81. June 2, 1972.

TRUE MURDER STORIES

SO LONG, LAKE ERIE

by Claire Jones, Steve J. Gadler, and Paul H. Engstrom

The killing of Lake Erie is a mob job – the combined efforts of some 11 million people who live near its shores and along the rivers and tributaries that empty into it. They are being aided and abetted by 360 industrial companies that discharge their wastes into the water.

Nine million people in the area are served by sewers and sewage treatment plants, but more than half of the plants give only primary treatment; that is, they strain out the solids and sludge, and then pump out the rest of the liquid without further treatment into the nearest waterway. Two million people live without sewers at all and discharge their raw wastes directly into the rivers and the lake. Thus sewage is one of the main sources of pollution in Lake Erie.

Giant industries discharge 9.6 billion gallons of water a day into the lake and its rivers, much of it contaminated with dangerous and filthy pollutants. These include acids, oil, cyanide, iron, phenol, and toxic metals such as copper, cadmium, chromium, lead, nickel, zinc, and iron. Poisonous chemicals enter the water from pesticides off agricultural land and from plastics and chemical industries. Phosphates pour in from fertilizers and detergents.

Also, power plants contribute thermal pollution to the water. And the radioactive content of the lake is rising, partly from the increasing numbers of atomic power plants being built along the shores.

Other pollutants in the lake include oily wastes, fish entrails, and human excrement from commercial and pleasure boats. In addition, spoil from harbor dredging – 6 million cubic yards each year – is dumped into the middle of the lake. Soil particles picked up from eroded land areas and from highway and urban development also clog the water. Trash and debris are widespread at all depths of the lake.

All of these pollutants have varied effects on Lake Erie. Some use up the oxygen in the water when they decay. Others overstimulate the growth of the underwater plants, leading to accelerated eutrophication, so that even more oxygen is lost. Some pollutants are poisonous, killing plant life, microorganisms, and the fish that feed upon them. And the decay of all this matter causes even more decomposition and loss of oxygen. Other pollutants color and obscure the water so that the sunlight cannot get through, causing the death of organisms that depend on sunlight. The inevitable result, if the pollution of Lake Erie continues, is a dead lake – water that is of no value to man or animal.

Eighty-seven beaches on Lake Erie were closed down by 1968. Commercial and sport fishing declined disastrously, and now there are restrictions on the sale of fish caught in Lake Erie because they are so contaminated. Some species of fish have disappeared altogether. Ships are prohibited by the Public Health Service from taking drinking water out of the lake unless they are equipped to give it full cleansing treatment. In Cleveland, the inadequate sewage treatment system is allowing raw sewage to contaminate the residents' own drinking water. A doctor in the area made tests which showed that there were dangerous germs in water that had sat in the pipes overnight. He regularly treats patients for vomiting and diarrhea after they have drunk water or eaten food out of the lake.

Erie is a tough little lake. Because it receives a high volume of good quality water from Lake Huron and empties out vigorously over Niagara Falls, it has a rapid flush-out time. This helps to replace the polluted water with cleaner water. But the attacks upon Lake Erie are now so strong and so unceasing that little hope remains for its survival.

The forces of law and conservation are making rumbling noises, threatening to take action against the industries and cities that are the major polluters. But they are going to have to move fast, enforce the spending of vast amounts of money, and do a major clean-up in record time if Lake Erie is to be saved.

In 1970 federal investigators reported that most cities and some industries were falling far behind pledges they had made earlier to clean the water that flows into Lake Erie. The federal government also was accused of failing to provide the money it had promised and of failing to clean the waste waters under its own control.

Pollution: The Waters of the Earth by Claire Jones, Steve J. Gadler, and Paul H. Engstrom, copyright 1970 by Lerner Publications Company. Reproduced by the publisher. All rights reserved.

ABOUT THE AUTHORS OF *TRUE MURDER STORIES, SO LONG LAKE ERIE*

Pollution: The Waters of the Earth is one of eight books on pollution written by Claire Jones, Steve J. Gadler, and Paul H. Engstrom. This volume was a cooperative effort, each person contributing his or her own knowledge and experience, with the final result a kind of "literary synergism."

Paul H. Engstrom is a minister, a lawyer, and a family counselor, as well as president and cofounder of the Minnesota Environmental Control Citizens' Association. Under his leadership, MECCA has worked for preservation of Lake Superior and the Mississippi watershed, reduction of radioactive pollution, reuse of materials in solid waste, and many other environmental goals to improve the quality of life. Thus Rev. Engstrom's major contribution to this series of books on pollution was a social and legal perspective resulting from direct experience.

Steve J. Gadler also is experienced in the fight to save the environment: he is a registered professional engineer who was an environmentalist long before pollution became a national issue. A retired Air Force Colonel, Mr. Gadler has for many years been asking pertinent, revealing questions about the damage caused by our industrial society. He has been especially concerned about radioactivity, which is an invisible but deadly threat to life itself. In 1967, the governor of Minnesota appointed him as a member of the state's Pollution Control Agency. Mr. Gadler's technical expertise is apparent in each book in the series.

Claire Jones is an experienced writer who first became aware of the dangers of pollution in 1956, when she lived through one of the famous London killer smogs. Teaming up with Rev. Engstrom and Mr. Gadler gave her an excellent way to express her concern over the condition of the environment. However, her contribution had been more than a concerned citizen's point of view and a crisp, sparkling writing style. A native of England, Mrs. Jones brings a special international outlook to this series. None of the problems of pollution can be seen as less than worldwide, and this important perspective gives *The Waters of the Earth* added value.

LAKE ERIE

by James P. Barry

Introduction

Lake Erie is one of the best known bodies of water in the country. It is well known in a negative way – nearly everyone has heard that the lake is badly polluted. That is certainly true. But many things that have been written or said about Lake Erie are not true. The lake is not a swamp, it is not dying, it is not without fish. There are places where it is beautiful, there are places where you can go swimming, and the fish catch is reaching record proportions. At the same time, the lake has many problems. This article will tell you what some of them are, how they developed, and what we can do and are doing about them.

What Happened to the Lake

As our country grew, all the things that people did on the land also affected the lake. When forests were cleared for farming, the land itself often washed into the lake; the Maumee River which flows into the western end of Lake Erie carries silt all the way from Indiana farmlands and piles it on the bottom. And as cities grew around the lake, their sewage and factory wastes were usually piped directly into it or into the rivers flowing to it.

By 1970 nearly everyone saw what bad condition the lake was in. It had many problems caused by oil and industrial chemicals. But the worst problems were caused by sewage, by fertilizer that washed off fields, by other material acting as nutrients to the algae and other tiny plants in the water causing them to grow. Eutrophication is the process of aging and it is speeded up if people pollute or partly fill in a lake of normal size. People have certainly polluted Lake Erie, and in a sense they have partly filled it in by causing silt and sediments to wash into it. This action has caused the kinds of plants and fish to change and the numbers of them to increase. So to some extent, Lake Erie has been affected by this aging process of eutrophication. This fact has caused some people to say that the lake is dying, but Lake Erie is so large that the rules pertaining to smaller lakes do not fully apply to it. If we continue polluting the lake over a long period, eutrophication could pose a serious threat. But today many of the ways we have damaged the lake can still be corrected, and a number of things are now being done to correct them.

What Is Being Done

The material that causes the most trouble in Lake Erie is phosphorus, for it is the phosphorus in sewage, in fertilizer washing in from the fields, and in other sources that feeds the algae and makes them grow. (Sewage contains phosphorus both in human wastes and in the great amount of detergents that we use for washing and then drain into our sewage systems.) Perhaps the next biggest problem comes from bacteria that can cause disease. When they are in water, swimming can be dangerous and beaches must be closed.

Much of the phosphorus and most of the dangerous bacteria come from sewage, and so the first thing that was done to help the lake was to build more sewage treatment plants and to make the old plants better. Hundreds of millions of dollars in federal grants (administered in Ohio by the Ohio EPA) were given to towns and cities for their treatment plants. Cleveland, for example, has a treatment system that serves over 1,280,000 people in Cuyahoga County and that was first built many years ago to take care of far fewer people. There are three treatment plants in Cleveland. Both the network of sewer lines and tunnels running to these plants, and the plants themselves, are being rebuilt and improved. The work will continue over several years and will cost about $500 million. Similar programs are going on in towns and cities all around Lake Erie. The main purpose of all this work is to keep phosphorus and disease germs out of the lake now and in the future.

Another important kind of pollution comes from toxic substances. These range from pesticides that were used on farms and orchards and then washed into the lake to chemicals drained into the lake by industry. These substances can kill or deform fish, birds, and other animals, and also can be carried in the flesh of animals that seem healthy. A person who eats such a fish or bird or muskrat can absorb some of the poison and may be affected by it. Most of the dangerous pesticides have now been banned by law. Another poison, mercury, is no longer being drained into the lake and may, in time, gradually disappear from it.

There are other poisons in the water and in the mud on the bottom, but the chemicals called PCBs seem to cause the most problems today. They have been used in making a great number of items for the past forty years, and so they not only are in the bottom mud but also, things made of them are at many locations around the shore, where rain and snow can wash over them and carry PCBs to the lake. And PCBs are still used in some manufacturing. Ways of controlling them are being studied, and the U.S. and Canadian governments have passed or are in the process of passing laws that limit their use.

The Situation Today

Lake Erie is still polluted, but the flow of pollution into the lake is slowing. Today the lake is at a point of balance; in years when the water level is high and more water flows through the lake, diluting and washing out the pollutants, it gets better, but in other years it does not. At certain places around the shore, however, the water is definitely better than it was. There are places where new or better sewage treatment plants have been built, or where other local action has been taken to stop pollution. As one result, most of the beaches that were closed because of pollution have been opened again. And walleye, one of the preferred kinds of fish, is coming back to the delight of hundreds of sport fishermen. But we must keep working to repair the damage we have done to the lake. There are still significant problem areas that remain to be corrected. The cost of cleaning it up is not great if we think in individual terms. Experts believe that to clean up the lake it would cost each person living on its shore, each year, about the same amount as a carton of cigarettes or a day's food. That is a price we can afford to pay for Lake Erie. What we must do now is get together and do the job.

ABOUT THE AUTHOR OF *LAKE ERIE*

James P. Barry is an author and photographer who specializes in Great Lakes subjects. He made his first voyage on a lake freighter at the age of eight, graduated from The Ohio State University with distinction, and has written 10 books, half of them dealing with various aspects of the Lakes.

This article was adapted from a pamphlet prepared for the Ohio Environmental Protection Agency, March 1980.

LAKE ERIE

Section 7.4, *State of the Great Lakes*, 1995.

Lake Erie is the smallest of the Lakes in volume and second smallest in area. Yet it is still the tenth largest freshwater lake in the world in terms of surface area and 16th in volume. Of all the Great Lakes it is exposed to the greatest stress from urbanization and agriculture. The Lake receives runoff from the rich agricultural lands of southwestern Ontario and parts of Ohio, Indiana and Michigan. Seventeen metropolitan areas of over 50,000 population are located within its basin. The basin population is approximately 13 million with approximately 88% of the population within the U.S. . . .

There are eight Areas of Concern on Lake Erie . . ., but four more from the Detroit and Sarnia areas contribute to its problems. The Buffalo AOC has little affect on the Lake as most of its discharge is drawn into the Niagara River and into Lake Ontario. Presque Isle, Pennsylvania and Wheatley Harbour, Ontario are relatively small, but the others are major problem areas. The Ashtabula, Cuyahoga, Black, Maumee and Raisin River areas all present formidable problems as do the St. Clair, Clinton, Detroit and Rouge River areas upstream.

The Lake is large in area, but the average depth is only about 19 metres (62 feet). It is the shallowest and therefore warms rapidly in the spring and summer and frequently freezes over in winter. It also has the shortest retention time of the Lakes, 2.6 years. The western basin, comprising about one-fifth of the Lake, is very shallow with an average depth of 7.4 metres (24 feet). The waters of the Lake, like the surrounding farm lands, are highly productive: far more productive than the other Lakes.

Although the Lake Erie basin is the most intensively populated and farmed, pollution loading has been mitigated through sedimentation from the productive algae and fine soil particles from farmland erosion.

Therefore, with respect to toxic contaminants, Lake Erie organisms have historically shown relatively low concentrations compared to the other Lakes. As eroded soil and nutrient levels decline and zebra mussels deplete algal populations, this may change, increasing rates of bioaccumulation.

In terms of environmental quality, Lake Erie is severely degraded with respect to habitat. Although never "dead" as reported in the 1960's, it was severely stressed by eutrophication stimulated by excess nutrients. The resulting algal blooms closed beaches, disrupted food chains and aquatic communities, and caused wide spread oxygen depletion in the central basin. Massive investment in municipal and industrial waste treatment and voluntary programs to control agricultural land runoff have produced excellent results. They have achieved target levels and are producing the biological results expected. Oxygen depletion still occurs in the bottom waters of the central basin, but to a diminishing extent. Phosphorus concentrations in the western basin have nearly reached target levels but sediment resuspension during storms results in recycling of nutrients from bottom deposits.

The near total removal of native vegetation from the basin, and severe exploitation of fisheries followed by exotic species invasions, have devastated the original aquatic community of the Lake. Recovery is under way, but the long term nature of the resulting community is unknown. Species having particularly heavy impact include zebra mussels, and carp. Others such as alewife, smelt, white perch, pacific salmon, and most recently the round goby have added stress to the system.

Zebra and quagga mussels are closely related exotic species that prefer habitats typical of Lake Erie. The two species are very similar, a major difference being that quagga prefer deeper water than zebra mussels. Without any natural predators or diseases, their populations have exploded. Both mussels are voracious filter feeders, and as such, have had profound effects on the Lake's ecosystem including abrupt changes in water quality, water clarity and the food web. By consuming large amounts of phytoplankton, they have increased water clarity (a 77% increase in water transparency has occurred between 1988 and 1991). By increasing the clarity of the water, sunlight is able to penetrate deeper, allowing rooted aquatic plants to spread into deeper water. This has had ecological benefit to many organisms but has interfered with swimming and boating in some areas.

The eating habits of mussels have led to large changes in the food web which may result in major changes in the future abundance of various species of fish. They have depleted the food source (phytoplankton) for other filter feeders, and have also assimilated toxic contaminants. By removing large amounts of particulates, which formerly absorbed/adsorbed pollutants, more contaminants are left in the water. This could result in higher contaminant concentrations in the remaining phytoplankton and zooplankton as well as higher concentrations in fish and wildlife species feeding on the plankton or directly on the mussels and other benthos (bottom dwellers). The results of the zebra mussel invasion have become far more complex than the physical problems of clogging intake pipes or jamming machinery.

Although not yet established in Lake Erie another exotic species to be concerned with is the ruffe. Ruffe habitat consists of warm shallow water such as found in much of Lake Erie. In fact, considering all of the Great Lakes, Lake Erie has over half the thermally suitable habitat. Potential effects of large populations of ruffe on fish communities are unknown, but if it were to become as abundant in all the thermally suitable habitat as it did in the St. Louis River estuary of Lake Superior, it would be a major problem for the Great Lakes fisheries. A decline in the yellow perch abundance similar to that seen in the St. Louis River estuary would seriously impact the fishery which is presently valued at $141 million Can. ($101 million U.S.) in Lake Erie alone for yellow perch.

Historically, the top commercial fish in Lake Erie included whitefish, walleye, blue pike, lake trout (only found in the eastern basin of Lake Erie in the colder deeper waters) and sturgeon. The demise of the lake trout was mainly a combination of overharvesting and environmental stress. The populations of whitefish, walleye and sturgeon have diminished from overfishing and blue pike became extinct. In 1970 high levels of mercury led to the closure of the commercial walleye fisheries in the U.S. and Canada as well as restrictions on the retention of walleyes caught by anglers. After 1972 the mercury levels had declined and the walleye fishery re-opened in Ontario to both sport and limited commercial use; however in Michigan and Ohio it was restricted to angling. Due to the relief from commercial fishing and to the quotas imposed after re-opening the fishery, the walleye fishery of the western basin has shown a spectacular recovery.

Some fish consumption advisories are in effect for lake trout, chinook salmon, coho salmon, walleyed pike, smallmouth bass and white bass. As in other lakes, advisories differ by species, size and location so it is important to check with the appropriate state or province.

A LaMP (Lakewide Management Plan) is currently being developed for Lake Erie, in accordance with the GLWQA, between the Canadian and U.S. federal governments, the four Great Lakes states (Ohio, Michigan, Pennsylvania, and New York) and the province of Ontario. The goal of the LaMP is to restore and protect the beneficial uses of Lake Erie using an ecosystem approach. It will address critical pollutants, habitat loss, exotic species and natural resource management including fish community objectives. Fish community objectives are being developed in response to the Strategic Great Lakes Fisheries Management Plan and are currently under review.

Four critical pollutants have already been identified for immediate action: PCBs, DDT and metabolites, chlordane, and dieldrin, and the remainder of pollutants will be identified through the beneficial use impairment assessment. LaMP activities will closely coordinate with the Remedial Action Plans for the AOCs in the Lake Erie drainage basin, as well as coordinating with programs downstream such as the Niagara River Toxic Management Plan and the Lake Ontario LaMP.

(Source: *State of the Great Lakes 1995*. Prepared by Environment Canada and U.S. E.P.A.
Refer to Section 7.4 Lake Erie pp. 44-47.)

ABOUT THE AUTHORS OF *STATE OF THE GREAT LAKES 1995*

"The report was written by several different employees of U.S. EPA and Environment Canada drawing upon materials . . . developed for the 1994 State of the Lakes Conference. Educational levels ranged from BS to PhD in various scientific fields. (The) intent was to write for a general readership assuming some level of interest in the topics."

Source: Fuller, Kent. SOLEC 1995. [electronic mail to the editor]

Great Lakes Water Quality: Background and Issues

The Boundary Waters Treaty of 1909 was created to prevent and resolve disputes along the boundary between the United States and Canada, particularly those concerning water resources. The Treaty states that neither country shall pollute boundary waters to the injury of health or property on the other side. This commitment is echoed in the Great Lakes Water Quality Agreement first signed in 1972, which provides a framework for cooperative and coordinated national programs to restore and maintain the chemical, physical and biological integrity of the waters of the Great Lakes Basin Ecosystem. The International Joint Commission (IJC) was asked by the Governments to monitor progress under the Agreement. Among other things, the Commission reviews progress and advises Governments — through biennial reports and other means — on Great Lakes water quality matters.

The purpose of the "Parties" to the Agreement is to restore and maintain the chemical, physical, and biological integrity of the waters of the Great Lakes Basin Ecosystem. In order to achieve this purpose, the Parties agree to make a maximum effort to develop programs, practices and technology necessary for a better understanding of the Great Lakes Basin Ecosystem and to eliminate or reduce to the maximum extent practicable the discharge of pollutants into the Great Lakes System.

Some of the regulations and initiatives that support Great Lakes water quality include:

- **Great Lakes Water Quality Agreement of 1978, Article II**
  Laws and initiatives in Canada and the United States have created the building blocks for comprehensive action on environmental concerns. The Agreement has provided a binational framework for these initiatives within an ecosystem approach to environmental management for the Great Lakes. It has served as an outstanding example of what two countries can do with vision and commitment. The Agreement's community of scientists, informed officials, and volunteers has become a world-class example of binational cooperation and environmental stewardship.

  Investments in sewage treatment, stormwater runoff management, controls on industrial discharges, shipping and dredging, and limited bans on phosphorus and certain pesticides have produced significant results. Other initiatives, including the Lake Superior Binational Program, Remedial Action Plans, and rural nonpoint strategies, have focused attention on best management practices and needed local actions.

- The **Great Lakes Water Quality Initiative (GLI)** is intended to bring together federal water quality criteria in a uniform plan, and make it simpler to implement procedures in the U.S. portion of the Great Lakes basin. It is also designed to help the U.S. work with Canada under the Great Lakes Water Quality Agreement. The GLI established water quality criteria for 29 pollutants, addressed nonpoint and point sources, and established antidegradation policies. It incorporated the concepts of prevention, precaution, and weight of evidence and local empowerment.

- The **Joint Great Lakes Five-Year Strategy** commits U.S. EPA and its federal, state and tribal partners to programs to fulfill Agreement goals. It was expected to drive many actions identified in the United States' September 1995 report to the Commission, Great Lakes Program Progress Report, including actions to achieve zero discharge and virtual elimination.

- The **Canada-Ontario Agreement (COA)** facilitates federal and provincial cooperation to implement the Great Lakes Water Quality Agreement in Canada. In 1994, joint specific objectives and milestones by the year 2000 were formulated in three broad areas: restoring degraded areas; pollution control and prevention; and conserving and protecting the Great Lakes ecosystem, including human health. Areas needing further attention are human health research, water conservation, remediation of Areas of Concern, and progress towards zero discharge for most persistent toxic substances.

- **Great Lakes 2000** provides a focus for several Canadian federal programs. They include restoring Areas of Concern, preventing and controlling pollution, and conserving human and ecosystem health. As of January 1996, the Canadian Great Lakes Cleanup Fund had provided $14.8 milliion for habitat restoration and a total of $43 million for all Great Lakes projects; an additional $79 million was provided from other sources. Several worthwhile projects are under way at this writing in 1997.

- **Health effects programs**. An important U.S. program, the Agency for Toxic Substances and Disease Registry (ATSDR), has recently studied the health of people who consume Great Lakes fish. Health Canada is researching the health effects of air pollutants, drinking water, and other routes of exposure to contaminants, including specialized studies on high-risk populations such as native people. While not formally linked in a binational program, scientists and officials in the two countries are cooperating and exchanging information as the studies progress. These studies are critical to understanding health effects of persistent toxic substances.

VIRTUAL ELIMINATION AND ZERO DISCHARGE

> "It is the policy of the Parties that...the discharge of toxic substances in toxic amounts be prohibited and the discharge of any or all persistent toxic substances be virtually eliminated."
> *Great Lakes Water Quality Agreement of 1978, Article II*

There are various interpretations of virtual elimination and zero discharge. Virtual elimination is not a technical measure but a broad policy goal. This goal will not be reached until all releases of persistent toxic chemicals due to human activity are stopped.

Zero discharge does not mean simply less than detectable. It does not mean the use of controls based on best available technology or best management practices that continue to allow some release of persistent toxic substances, even though these may be important steps in reaching the goal. Zero discharge means no discharge or nil input of persistent toxic substances resulting from human activity. It is a reasonable and achievable expectation for a virtual elimination strategy. The question is no longer whether there should be virtual elimination and zero discharge, but when and how these goals can be achieved."
Eighth Biennial Report on Great Lakes Water Quality, 1996

Additional information and updates can be found at the Internet site for the Great Lakes Information Management Resource (http://www.cciw.ca/glimr), Great Lakes Information Network (www.great-lakes.net/) and the IJC website (http://www.ijc.org).

(Source: Excerpted from the Eighth Biennial Report of the International Joint Commission, Windsor, Ontario, 1997.

How much is one part per million?

Many potentially dangerous chemicals can be harmful in small concentrations. The level of polychlorinated biphenyls (PCBs) in a solution, for instance, is considered dangerous when there are only two parts of PCB for every million parts of solution. In this investigation students determine the extent of dilution necessary for a substance to have a concentration of a few parts per million.

PCBs are virtually indestructible pollutants produced by people for use as coolants in electrical equipment. They have escaped into the environment and are now found in food and water sources. They are thought to enter bodies of water such as Lake Erie through the air as a result of burning plastic objects containing the chemical, from direct dumping of liquid waste from industries using PCBs in their industrial processes, and from water running through solid waste disposal sites where transformers or other PCB-containing materials have been dumped. Although the United States production of PCBs has ceased, it is estimated that 450 million pounds of PCBs exist in the environment, and 750 million pounds of PCBs are still in industrial and domestic use in the 1990s.

Bioaccumulation of a toxin (such as PCBs) occurs when a toxin collects in the body of the organism that ingests the chemical. The toxin PCB is soluble in fat, which means that it collects in fatty tissue. PCBs are present in small concentrations in some of the waters of the Great Lakes. As fish and other organisms live in these waters, the PCBs collect in their fatty tissue so that the concentration of PCB in their bodies is much higher than in the water around them. The longer they live, the more toxins accumulate. If a bird eats several fish that are contaminated by PCBs, then that bird "collects" the toxins from each of those fish. In this manner, the PCBs are passed up the food chain at higher and higher levels of concentration.

Evening Post
6 ppm PCB in Fish!
?

Objectives

When you have completed this investigation you should be able to explain to someone about the concentration of PCBs that is considered to be dangerous.

Suggested Approach

The first part of this activity is written as a teacher demonstration. It (through Step II) could be conducted as a student lab if sufficient equipment were available.

Materials

Demonstration:
- India ink.
- Two eyedroppers.
- Graduated cylinders: 10 ml, 100 ml, and 1000 ml (or a liter vessel).
- Two 10- gallon aquaria or one 15 to 20-gallon aquarium.

Source

Modified from OEAGLS EP-23, *PCBs in Fish: A Problem?* Activity A, by Victor J. Mayer, Amy J. White-Predieri, Vanessa J. Steigerwald, and Stephanie Martin.

Earth Systems Understandings

This activity focuses on ESU 3 (science process and technology).

Teacher's Note

Concentrations of substances in solution are expressed as parts of the substance to the total parts of the solution. Therefore, if there were a solution of 1 part of ink and 9 parts of water, the concentration would be expressed as 1 part in 10. Discuss this with your students as you begin the activity.

At each step of the dilution, hold the vessel containing the solution in front of a white sheet of paper, and ask the class whether they can still see the ink. Alternatively, pour a small amount into a petri dish and display it on the overhead projector.

Answers

1. 1 part/drop of ink
2. 9 parts/drops of water
3. 10 total drops
4. 1/2 ml (There are 20 drops to a milliliter.)
5. 1/2 ml x 10 = 5 ml
6. There were 10 drops in the original solution.
7. 90 parts (drops) must be added.
8. There are 100 total parts (drops) in the solution.

PROCEDURE: STEP I

To begin this investigation, your teacher will place one drop of a colored material, probably ink, in a 10 ml graduated cylinder. Then your teacher will add nine drops (parts) of water. Answer the following questions on a sheet of paper.

1. How many parts (drops) of ink are in the cylinder?
2. How many parts (drops) of water are in the cylinder?
3. How many total parts (drops) of solution are in the cylinder?

Since your teacher has 10 drops of solution that has 1 drop of ink in it, the concentration of solution is described as 1 part ink per 10 solution. This ratio can be written 1 part ink: 10 parts solution or 1 part ink / 10 parts solution.

4. Look carefully at the graduated cylinder. What is the volume of the solution?

Keep a record of all the data from Step I in the data chart.

STEP II

In Step I we had 1 part ink in 10 parts solution. Now we want to dilute the ink in solution by adding more water. The concentration of ink will be reduced because more water will be added.

In Step II we want to dilute the solution 10 times.

5. What volume of solution is 10 times greater than the original volume of solution?
6. How many parts (drops) were in the original solution?
7. How many parts (drops) of water must be added to dilute this solution 10 times?
8. Now, what is the total number of parts (drops) in the solution?

Add the data from Step II to the data chart. Be sure to note on your paper what the concentration was when you were unable to see the ink because it was diluted too much.

STEP III

Our original drop of ink is now diluted to 1 part per 100. Let's keep diluting this solution until the ink is diluted to 1 part per million.

9. What volume in milliliters would be ten times greater than the volume we have obtained in Step II?

9. 50 ml is 10 times greater than 5 ml.

Our 10 ml graduated cylinder is too small to hold this volume, so the teacher must transfer our solution into a larger 100 ml graduated cylinder. Then the teacher will add water to dilute the solution to the volume you have calculated in question 9. Instead of counting drops as in Step II, you can calculate the number of drops (parts) of total solution using the equation:

20 drops (parts) = 1 milliliter

10. How many total parts (drops) of solution are in our newly diluted solution? Record the data in the data chart.

10. There should be 1,000 parts (drops).

STEP IV

11. If we dilute the new solution 10 more times, what volume (in milliliters) of solution would we have?

11. There would be 500 ml of solution.

12. What volume in liters would be equal to the number of milliliters in question 11?

12. 0.5 liters is equal to 500 ml

13. Using the equation 20 drops (parts) = 1 ml, how many total drops (parts) of solution are contained in the volume obtained in question 11?

13. There would be 10,000 parts (drops).

Your teacher will make the dilution to the volume you calculated in question 11. A liter vessel must be used to hold the solution since the 100 ml graduated cylinder is too small. Tabulate your results for Step IV in the data chart.

Data Chart Answers

I	II	III	IV	V final step
1:10	1:100	1:1000	1:10,000	1:1,000,000
1/2 ml	5 ml	50 ml	500 ml	50,000 ml

DATA CHART

STEPS	I	II	III	IV	V final step
PARTS	1:10				
VOLUME	1/2 ml				

14. Two additional dilutions. One dilution will take it to 100,000 drops and the second to 1,000,000 drops.

15. For the first dilution you will end up with 5,000 ml or 5 liters of solution and for the second, 50,000 ml or 50 liters of solution.

16. 13.2 gallons

17. After a concentration of 1:1000 has been reached, students will find it difficult to see any indication of the presence of the ink.

Teacher's Notes

You might want to bring out some other comparisons of what one part per million means. For example: it is 1 minute in 2 years; one second in 11.6 days, 1 penny in $10,000, and 1 ounce of chocolate in 8,000 gallons of ice cream.

In 1990, Congress amended the Great Lakes Critical Programs Act, also known as the Federal Water Pollution Control Act. The amendment mandated that the Environmental Protection Agency (EPA), in consultation with the Agency for Toxic Substances and Disease Registry (ATSDR) and the Great Lakes states, submit to Congress by September 30, 1994, a research report assessing the harmful human health effects of water pollutants in the Great Lakes basin. (Source: Great Lakes Human Health Effects Research Program, November 1994, Executive Summary – http://atsdr1.atsdr.cdc.gov:8080/grtlakes.html)

See http://atsdr1.atsdr.cdc.gov:8080/CHEM/PCB.gif for an image of the molecule. Web addresses sometimes change. Do a word search if necessary.

STEP V

14. How many more tenfold dilutions are necessary to dilute the ink to one part per million? Explain how you arrived at this answer.

15. What volume (in liters) of solution is necessary to perform each of these dilutions?

16. How many gallons of solution are needed to dilute the ink to a concentration of 1:1,000,000? HINT: 1 liter = 0.264 gallons.

As your teacher carries out the dilutions you have determined above, fill in the rest of the data chart.

17. At what concentration were you no longer able to see the ink?

EXTENSION

Contact industries to find out which and what levels of chemicals they add to the water or atmosphere. Conduct research to determine the amount of the pollutants that companies can legally add to the ecosystem. Examine the risks associated with various pollutants and decide whether you think the allowable amounts are appropriate. What points of view could/should be taken into consideration when deciding legal limits of pollution?

REFERENCES/ WEB SITES

http://www.epa.gov/glnpo/health/atsdr.htm
The Effects of Great Lakes Contaminants on Human Health, Report to Congress.

http://atsdr1.atsdr.cdc.gov:8080/grtlakes.html
ATSDR (Agency for Toxic Substances and Disease Registry) Great Lakes Human Health Effects Research Program.

http://atsdr1.atsdr.cdc.gov:8080/ToxProfiles/phs8821.html
Agency for Toxic Substances and Disease Registry, Public Health Statement, PCBs, ATSDR Public Health Statement, June 1989. This site answers questions such as: "What are PCBs?" and "How do PCBs affect my health?"

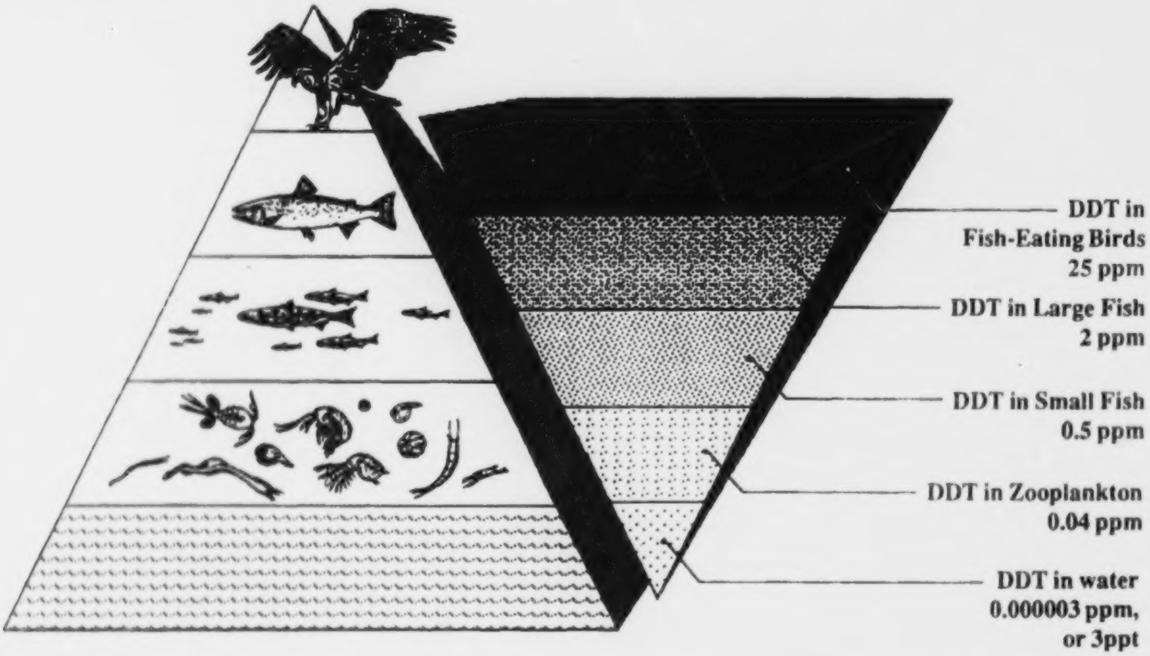
http://atsdr1.atsdr.cdc.gov:8080/tfacts17.html – ATSDR's ToxFAQs, Polychlorinated Biphenyls (PCBs), April 1993.

Which fish can we eat?

Bioaccumulation **of a toxin occurs when a toxin collects in the body of an organism. PCBs, a class of organic compounds, and DDT, a compound previously used as an insecticide, are toxins of concern in the Great Lakes, because they remain in the environment long after their use is prohibited.** When some toxins (such as PCBs or DDT) are ingested, they do not pass through the body of the organism but collect and accumulate in its body. High concentrations of toxins can cause a variety of health problems, genetic disorders, and death in humans and animals. The class of toxin called PCBs (polychlorinated biphenyls) is soluble in fat, which means that it collects in fatty tissue. The family of PCBs includes 209 compounds, and PCB products contain both the chemicals and added components. As fish and other organisms live in bodies of water that contain PCBs, they eat other organisms, such as plankton, which contain the toxins. As the fish ingest PCB-laden food, the toxins collect in their fatty tissue so that the concentration of PCBs in their bodies is much higher than in the water around them. The longer they live in those waters, the more toxins they accumulate from the organisms they consume. If a bird eats several fish that are contaminated with PCBs then that bird "collects" the toxins from each of the fish it eats. In this manner, the PCBs are passed up the food chain at higher and higher levels of concentration.

Some of the symptoms in humans associated with PCBs are cancer, neurological effects, and effects on reproduction and development. In wildlife, PCBs have been associated with premature deaths and effects on reproduction and the immune system. It is recommended that people not eat fish that have PCB concentrations of 2 parts per million or more.

Figure 1. Accumulation and amplification of organic contaminants in an aquatic system. Like PCBs, DDT is no longer produced in the U.S., but it persists in the environment. (Source: Green Bay/Fox River Mass Balance Study, Executive Summary, EPA-905/8-89-002, GLNPO Report 07-89, August 1989)


DDT in Fish-Eating Birds 25 ppm
DDT in Large Fish 2 ppm
DDT in Small Fish 0.5 ppm
DDT in Zooplankton 0.04 ppm
DDT in water 0.000003 ppm, or 3ppt

Materials

- Paper and pencil.

Earth Systems Understandings

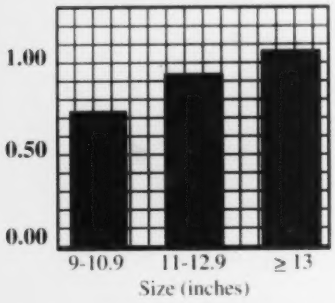
This activity focuses on ESU 2 (stewardship), 3 (science process and technology) and 4 (interactions).

Source

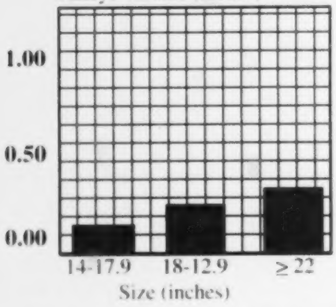
Modified from OEAGLS EP-23. *PCBs in fish: A problem?* Activity A, by Victor J. Mayer, Amy J. White-Predieri, Vanessa J. Steigerwald and Stephanie Martin.

Answers

1. Concentration of PCBs (ppm) in white bass vs. size (inches)



2. Concentration of PCBs (ppm) in walleye vs. size (inches)



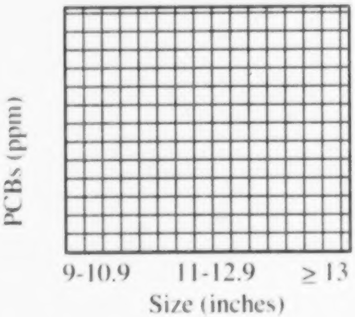
OBJECTIVE

After completing this activity you should understand some reasons why toxic concentrations vary in fish.

PROCEDURE

The Ohio Department of Natural Resources measured the PCB concentration in white bass and walleye in Spring 1987 and Fall 1987, respectively. Each was collected at three different places on Lake Erie. Table 1 has the data that were obtained.

1. Using Table 1 and the graph below, construct a bar graph of the data from Sandusky Bay for white bass (concentration of PCB vs. size of fish).



2. Construct another bar graph with the data from Middle Sister Island for walleye.

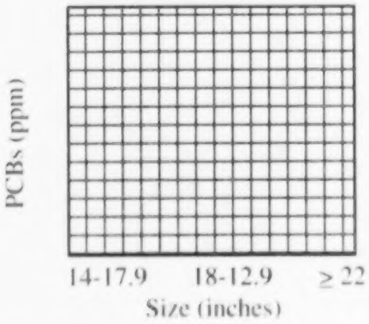


Table 1. Concentration of PCBs (ppm) in White Bass and Walleye taken from Lake Erie in Spring 1987 and Fall 1987, respectively.

WHITE BASS

Size	Maumee Bay	Cedar Point	Sandusky Bay
9-10.9"	1.34	0.66	0.74
11-12.9"	1.27	0.93	0.91
13" and over	1.64	0.96	1.06

WALLEYE

Size	Middle Sister Island	Cedar Point	Lorain
14-17.9"	0.16	0.16	0.15
18-21.9"	0.25	0.24	0.22
22" and over	0.33	0.36	0.42

3. Answer the following questions:

   A. How is fish size related to PCB content for the white bass at Sandusky Bay?

   B. Is the relationship between size and PCB content the same for the walleye at Middle Sister Island?

   C. What could cause this relationship?

   D. Now examine the data from the other sites. Does the relationship seem to hold for fish taken at each site?

   E. Compare the data collected for the concentration of PCBs in white bass and walleye. Which species contains higher concentrations of PCBs?

When comparing data, be careful to note the size categories. The walleye samples were larger than the white bass. Remember, PCB concentration should increase with size because PCBs bioaccumulate (i.e., concentrate in fatty tissues as fish become larger and older).

   F. Why might the concentration of PCBs be lower in walleye compared to white bass?

   G. Locate each of the sites on a map of Ohio. Is the concentration of PCB in the fish related to the site at which they are obtained? Which site seems to have fish with the highest concentration?

   H. Update the information on PCBs in Great Lakes fish by examining data from the Internet site http://CS715.cciw.ca/glimr/data/sogl-final-report. Investigate the figures, specifically Figure 10 (Source: Government of Canada). What seems to be the trend over the years for the amount of PCBs? Find the concentration of PCBs in fish from your lake and other Great Lakes as well.

> ***"Levels of persistent toxic contaminants have been reduced substantially since 1970."***
>
> *(Source: Government of Canada, 1996).*

Answers

A. The larger the fish, the higher the concentration of PCB.

B. Yes, the concentration of PCB increases as the fish increase in size.

C. This is probably true because the larger fish are older, and therefore have had more time to concentrate PCBs in their fatty tissues.

D. The relationship seems to hold at each site; however, the white bass at Maumee Bay deviate somewhat.

E. The white bass have higher concentrations of PCBs than the walleye, even though the white bass size categories sampled were smaller than those for walleye.

F. The walleye may have lower PCB concentrations because they tend to inhabit the open, cooler waters of the lake more than white bass. Thus, local sources of contamination such as industrial wastes or industrial dump sites on the adjacent land would be more dilute by the time they reached the farther, cooler open waters where walleye feed. Additionally, bottom feeders of the lake such as carp and catfish would be expected to contain higher PCB concentrations than both walleye and white bass. Both carp and catfish tend to remain close to shore and therefore uptake higher concentrations of local sources of contamination from industrial wastes and industrial dump sites on the adjacent land.

G. The concentrations did differ according to the sites at which the fish were obtained. This may be related to local sources of contamination such as industrial wastes or industrial dump sites on the adjacent land.

H. "Levels of organochlorine contaminants in the tissues of top predator and forage fish declined significantly from the late 1970s to mid 1980s but have shown a slower rate of decline more recently. (Levels . . . in some areas continue to be high enough to restrict consumption by humans" (Government of Canada, 1996).

Public Health Advisories for Great Lakes Fish (1996)

	Restrict Consumption*	**Do not eat**
Lake Michigan	Lake trout over 23"(north of Frankfort) [A] Lake trout 20-23" (south of Frankfort) [A] Walleye over 22" [B]	Brown trout over 23" Carp and Channel catfish Lake trout over 23" (south of Frankfort) Whitefish over 23" (south of Frankfort)
Lake Superior	Lake trout 20"-30" [A]	Lake trout over 30" Ciscowet over 18"
Lake Huron	Brown trout over 21" [A] Lake trout up to 22" [A]	Lake trout over 22"
Lake Erie[1]	Walleye Freshwater drum (See State of Ohio Advisory)	Carp and Channel catfish
Detroit River *Lk. St. Clair*	Freshwater drum over 14" [B] Walleye over 20" White bass over 13" Smallmouth bass over 18" White perch over 10" Rock bass over 8" Largemouth bass Bluegill over 8" Freshwater drum over 14" Carpsucker over 18" Brown bullhead over 14" Northern pike over 26" [B] Carp over 22" [A]	Carp Channel catfish over 22" Muskellunge and Sturgeon
Lake Ontario*	White perch Coho salmon up to 18" Rainbow trout up to 18"	American eel Channel catfish Lake trout Chinook salmon Coho salmon over 21" Rainbow trout over 25" Brown trout over 18"

* Restricted consumption: No more than one meal per week, or

[A] Nursing mothers, pregnant women, those who anticipate bearing children, and children under age 15 should not eat these fish.

[B] The above-mentioned group should not eat more than one meal a month of these fish.

**Lake Ontario data from 1992

[1] Data obtained from Michigan Department of Community Health, Public Health Advisory; and State of Ohio Advisory, Meal Advice for Eating Lake Erie Sport Fish, printed in *Twine Line*, Ohio Sea Grant Program.

For the most up-to-date information, contact the Michigan Department of Community Health, Department of Environmental Epidemiology. Updated February, 1996. Phone: (517) 335-8350.

State of Ohio Advisory
Meal Advice for Eating Lake Erie Sport Fish

Fish	Number of Meals Suggested
Yellow perch	No Restrictions
Walleye Freshwater drum	One Meal a Week (52 meals/year)
Carp under 20" White perch Steelhead trout Coho salmon Chinook salmon over 19" Smallmouth bass White bass	One Meal a Month (12 meals/year)
Carp over 20" Carp from Maumee Bay (all sizes) Channel catfish Lake trout	One Meal Every Two Months (6 meals/year)
Channel catfish from Maumee Bay	Do **Not** Eat

Source: *Twine Line*. February 1996. Ohio Sea Grant Program.

Answer

1. There may be a range of student answers on this question. However, the data suggest that there should not be any problems in consuming white bass and walleye that have been taken from Lake Erie, since the recommended standard of 2 ppm was not exceeded at any of the sampling locations.

Answer

Larger fish are often older than small fish and have had more time to accumulate toxins.

See the role play that follows this activity for additional review questions.

Teacher's Note

Even if you do not do the role play in the following activity, find ways to introduce the important information in the roles and resources.

Extension Notes

In the minds of some anglers and charter boat owners, the *National Wildlife* article and other publications had an economic effect on fishing in the Great Lakes. The number of charter trips dropped, for example by as much as 50% in Wisconsin (Butterbrodt 1996). Some boat owners sold their boats, and some bait and tackle store owners also experienced an impact (Butterbrodt 1996). One observation is that the charter fleet declined from 1,200 boats to 340 on Lake Michigan in Wisconsin (Appleby 1996).

Many people believe that warning articles and fish consumption advisories do have an economic impact on fishing in the Great Lakes. For example, FDA maintained a 5ppm action level through the '70s to early '80s but then lowered it to 2 ppm. States follow different consumption advisories even though they may share the same Great Lake (Thomas, November 14, 1996). Students can investigate similar issues.

PCBs are found in Lake Erie fish – but are they dangerous? The Food and Drug Administration, using information from the occurrence of PCB poisoning in Japan and from studies of laboratory animals, has established a standard of 2 ppm of PCBs as the maximum allowable concentration in fish used for human consumption. The white bass and walleye are an important food and sports fish.

1. What would you recommend to a fellow sports fisher about eating white bass and walleye caught on a fishing trip to Lake Erie?

REVIEW QUESTION

Why is it often more dangerous to eat larger fish from the Great Lakes?

EXTENSION

Brainstorm what impact a "fishing scare" caused by possible contamination in fish in the Great Lakes would have on the sport fishing industry, commercial fishing and the states economy. What other impacts would there be?

Consider the 1996 "crazy cow" scare in Great Britain. The possibility that the disease known as "crazy cow" could spread to humans who eat contaminated beef caused many people to stop buying and eating beef (even though the connection between eating beef and catching the disease has not been proven). The economic repercussions of this scare on the beef industry climbed into the billions of dollars.

How might a Great Lakes fish scare be similar or different from the crazy cow scare? Consult the Michigan (http://www.dnr.state.mi.us/) and Wisconsin (gopher://gopher.dnr.state.wi.us:70/1) Departments of Natural Resources and the Great Lakes Sport Fishing Council (http://www.execpc.com/~glsfc/) for information on how charter fishing was impacted by the *National Wildlife* article "Are Great Lakes Fish Safe to Eat?" August/Sept. 1989, Vol. 27, No. 5, p. 16(4). See also the *Federal Register* June 29, 1979, Vol 44, no. 127, p.38330-38340 regarding the FDA reducing tolerances of PCBs in fish from 5 to 2 ppm.

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Downhower, Jerry F. *The Biogeography of the Island Region of Western Lake Erie*. The Ohio State University Press, 1988. 280 pp.

Environment Canada and U.S.E.P.A., 1995. *State of the Great Lakes*.
Request copies from:
Environment Canada or
867 Lakeshore Road
Burlington, Ontario
Canada
L7R 4A6

Environmental Protection Agency
Great Lakes National Program Office
77 West Jackson Blvd.
Chicago, IL 60604
U.S.A.

Fortner, Rosanne W. and Victor J. Mayer, editors. *The Great Lake Erie*. The Ohio State University Research Foundation, 1993. Ch. 15.

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PCBs, ATSDR Public Health Statement, June 1989. Agency for Toxic Substances and Disease Registry. http://atsdr1.atsdr.cdc.gov:8080/ToxProfiles/phs8821.html

The Great Lakes. An environmental atlas and resource book. 1995. Jointly produced by the Government of Canada and U.S. EPA. 3rd edition. Copies available from E.P.A. Great Lakes National Program Office, 77 West Jackson Blvd., Chicago, IL 60604

Top 20 Hazardous Substances, ATSDR/EPA Priority List for 1995 – http://atsdr1.atsdr. cdc.gov:8080/cxcx3.html – includes ranking of substances (i.e., PCBs are sixth).

ToxFAQ's Menu of Chemical/Hazardous Substances, Agency for Toxic Substances and Disease Registry (ATSDR) – http://atsdr1.atsdr.cdc.gov:8080/toxfaq.html. To find a fact sheet, click on the letter of the chemical name; some entries also show molecular models.

National Sea Grant Resources

Consult the National Sea Grant Depository database for publication information (http://nsgd.gso.uri.edu/search.htm)

See Also

Priority Contaminants of the Great Lakes – http://CS715.cciw.ca/glimr/data/sogl-final-report/table4.html
(Source: Government of Canada, 1995).

ATSDR Science Corner – http://atsdr1.atsdr.cdc.gov:8080/cx.html

U.S. E.P.A. *The EPA Great Waters Program: An Introduction to the Issues and the Ecosystems.* Office of Air Quality Planning and Standards, Durham, North Carolina 27711. EPA-453/B-94/030, April 1994.

Additional Resources

Appleby, Maxine. Fish Advisories. [Online] Available email: mappleby@execpc.com

Butterbrodt, Jim. Great Lakes Study Committee. Personal Interview. December 2, 1996.

Thomas, Dan. Contaminants in fish tissues and fish advisories. [Online] glsfc@maui.netwave.net

The results of an EPA study (1995) on fish consumption advisories are available on PC-based disks that can generate statistics and maps for a specific fish species, state, or pollutant. Refer to document number EPA-823-C-95-001 and contact:

The Environmental Protection Agency,
National Center for Environmental Publications and Information
11029 Kenwood Rd.
Cincinnati, OH 45242
Phone: (513) 489-8190
E-mail: waterpubs@EPAmail.EPA.gov

How should the public health be protected?

PCBs are virtually indestructible pollutants produced by people. They are thought to enter bodies of water such as the Great Lakes through the air as a result of burning plastic objects containing the chemical, from direct dumping of liquid waste from industries using PCBs in their industrial processes, and from water running through solid waste disposal sites where transformers or other PCB-containing materials have been dumped. PCBs are a petroleum product that will not burst into flames at high temperatures. PCBs were developed as insulating material and used in electrical transformers and capacitors. The compound has also been used in a variety of consumer products such as motor fuels, detergents, nylon, pesticides, plastics, paints and varnishes, adhesives, lubricants, printing inks, fluorescent light starters, waterproofing and fireproofing materials, and other products. These latter uses have been banned since 1971.

In 1968, the danger of PCB was revealed in an event in Japan. A rice plant had used PCBs as a coolant in pipes that circulated through the hot rice oil. The pipes had developed leaks, discharging the PCBs into the oil, which was then eaten by people who developed the disease. PCBs were found in concentrations of 2000 ppm. After eating rice from the plant, four people died and more than 1,000 others suffered symptoms such as stillbirths, miscarriages, skin disease, nervous disorders, hearing loss and discharge from the eyes, weakness, numbness of limbs, dark coloring of skin, swelling of eyelids, and disturbances in liver function. Babies born to mothers who had eaten the oil had skin discolorations. Recent laboratory studies have shown that monkeys fed PCBs developed reproductive problems, liver disease, acne, eye inflammations, weight loss, and loss of hair. Liver tumors or liver damage have also been produced in test animals such as chickens, rabbits, quail, mice, and rats that have eaten PCBs.

Severe PCB contamination of fish was discovered around 1976 in the Hudson River. Many fish had levels of PCBs as high as 200 ppm. A tolerance of 5 ppm was established for PCBs in fish. This level was later lowered to 2 ppm in 1985. At this time it was discovered that striped bass in the lower Hudson River and off Long Island Sound were contaminated up to 20 to 40 ppm. The commercial fishery for striped bass was closed, and there were prohibitions placed on the possession of sport fish. This prohibitions created a great amount of protest from anglers in the form of civil disobedience and violation of the regulation. The Department of Environmental Conservation decided to publish advisories against eating the fish instead of prohibiting people from catching the fish.

All anglers who get a license receive the advisory. Many anglers do not take these restrictions seriously and disregard them. Some anglers believe the advisories to be a political decision rather than one related to health risks. It has also proven to be difficult to reach many of the individuals who are subsistence fishes on the lower 90 miles of the Hudson river, where a fishing license is not required (including Native American groups).

These difficulties raise many questions as to the most effective way to protect the public health from toxins in fish.

Materials

- Set of role descriptions (included).

Source

Modified from OEAGLS EP-23. *PCBs in fish: A problem?* Activity B by Victor J. Mayer, Amy J White-Predieri, Vanessa J. Steigerwald, and Stephanie Martin.

Earth Systems Understandings

This activity refers to ESU 2 (stewardship), 3 (science process and technology), 7 (careers and hobbies), and 4 (interactions).

Roles

Experts (one student for each role):

- Scientist from the Federal Food and Drug Administration
- Officer of the New York Department of Environmental Conservation

Interest Groups (2 or more students each):

- Association for the Protection of the Health of New York Citizens
- Association of Local, Municipal, and State Public Officials
- The Marina Operators Association of New York
- The Sports Fishers of New York
- The New York Association of Commercial Fishers

The Board (3 or 5 members):

- This group asks questions and will ultimately decide the outcome of the role-play situation (the teacher may decide to include herself/himself in this group).

OBJECTIVES

After completing this investigation you should be able to:

1. Identify ways in which dangerous materials can enter the environment.
2. Describe the degree of danger in eating fish that contain PCBs.
3. Explain how to prepare fish to reduce the danger of eating harmful amounts of PCBs.
4. Discuss the possible effects of different ways of controlling PCBs upon the fish and sports industries.
5. Analyze the difficulties in taking action against the threat of PCBs.

THE SITUATION

Certain species of fish from the Great Lakes, according to fish advisories, still contain PCBs at a level that might be dangerous to the health of people eating them. The New York Department of Health is considering several policies for reducing the health hazard. In this activity, you will play the role of a member of an interest group or an expert concerned with contamination problems.

You will be part of a hearing similar to one that the Department of Health might hold to gain information and select policies. These policies will then be implemented and enforced throughout the state. At the end of your hearings, the board members will vote to decide what they consider to be the best policy.

THE POLICIES

The Department is considering the following policies:

I. Close Lake Ontario to any fishing.
II. Lower the allowable level of PCB concentration in fish to 1 ppm or less.
III. Restrict fish takes to only the smaller, and therefore less contaminated, of the affected species of fish.
IV. Close only those areas of the lake in which fish are found to have concentrations of PCBs above 2 ppm.
V. Develop and broadcast an advisory that tells the maximum amounts of fish that can be eaten without danger to health and describes ways to reduce the amount of PCBs from fish.
VI. Take no action.

[Teachers may wish to duplicate this box on card stock so each student can keep all the options in mind.]

PROCEDURE

1. The teacher will assign you a role and provide resources for developing your argument.

2. You will have time to study your role and to do any additional background research that you may find necessary.

3. Meet with your interest group or with others with similar roles to discuss the positions and make plans.

4. The hearing will be held and the following rules followed:

   a. The experts will present prepared remarks to the board.

   b. Each interest group will have no more than 5 minutes to present a prepared statement.

   c. Only members of the board may ask questions, and they must be directed to the presenter immediately following the presentation.

   d. When all presentations have been made, board members may ask additional questions of any of the presenters.

   e. Board members meet to decide on one of the policies.

Teacher's Note

Assign roles at least a day or two before you plan to start the simulation. Duplicate enough of the role descriptions so that each member of a role group can have the one pertaining to his/her role. Have the five policy options displayed in the classroom ahead of time so that the students can refer to them.

Answers to Review Questions

1. PCBs get into water through the air as a result of burning plastic objects containing the chemical; from direct dumping of liquid waste from industries using PCBs; and from water running through solid waste disposal sites where transformers or other PCB-containing materials have been dumped. Fish take up PCBs from the food they eat. The PCBs concentrate in the tissue, especially the fatty tissue, of the fish's body.
2. The data suggest that there should not be any problems in consuming white bass and walleye that have been taken from Lake Erie, since the recommended standard of 2 ppm was not exceeded at any of the sampling locations. However, bottom feeders such as carp and catfish would be expected to contain higher PCB concentrations and should probably not be consumed.
3. The threat of PCBs to human health can be reduced by trimming off the fatty tissue when filleting fish and avoiding the consumption of fish that have PCBs in concentrations above 2 ppm, the recommended standard.
4. The economies of towns along the lakes would be significantly affected if fishing was banned. Marina owners and operators, the charter boat business, and tackle and bait sellers would all be greatly affected. Allow students to brainstorm. Answers should include lost recreational spending (hotels, fishing equipment) and commercial interests.
5. Probably the most difficult policy to enforce would be the closing of Lake Ontario to any fishing because of all the opposition that would result. For instance, many sports fishers do not eat what they catch. However, closing only those areas of the lake in which fish are found to have concentrations of PCBs above 2 ppm would also be very difficult to enforce. It would be difficult to keep track of the closed areas.
6. The answers to this questions will vary. The reasons for students' choices are important to note. Hold a class discussion and compare the reasons in favor of each policy.

REVIEW QUESTIONS

1. How do PCBs get into water? Into fish?
2. How dangerous is it to eat fish from the Great Lakes? Why?
3. List ways in which the threat of PCBs to human health can be reduced.
4. How would banning the taking of fish from the Great Lakes affect the economies of towns along the lakes?
5. Which of the policies would be most difficult to enforce? Why?
6. Which policy would you support? State your reasons.

EXTENSION

Talk with restaurant owners or fishers who sell or catch Great Lakes fish. Ask them what they know about the health risks associated with the fish and how this knowledge has changed their practices. Decide whether you think that people have enough knowledge about toxins in Great Lakes fish.

REFERENCES

Horn, Ed. 1993. *Risk Assessment, Communication and Management in the Great Lakes Basin.* Article titled "Use of Risk Assessment and Risk Management in Relation to Fish Advisories" International Joint Commission.

Schmidt, Wayne A. 1989. "Are Great Lakes Fish Safe to Eat?" *National Wildlife.* Vol. 27, No. 5 (August-September): 16 (4).

SCIENTIST FROM THE FEDERAL FOOD AND DRUG ADMINISTRATION (FDA)

The FDA is responsible for ensuring the safety and wholesomeness of all foods sold in interstate commerce except for meat, poultry, and eggs, all of which are under U.S. Department of Agriculture (USDA) jurisdiction. The USDA and the FDA have been routinely inspecting fresh fruits and vegetables, dairy products, eggs, grains, fish, animal feeds, and processed foods for high concentrations of PCBs. The tolerance level for PBCs in fish and shellfish was set at 2 ppm in 1985 (The FDA develops standards for the composition, quality, nutrition, and safety of foods, including food and color additives).

Polychlorinated biphenyls (PCBs) are virtually indestructible pollutants produced by people and now found in food and water sources. For almost 50 years, this toxic chemical has been used in numerous products. Each year, millions of pounds of PCBs have been dumped into rivers and waterways through industrial waste disposal and accidental spills, leaked into the soil from trash in dumps and landfills, and carried into the air from burning of waste and vapor escaping from paints and varnishes. PCBs are chemically stable and not easily broken down. Complete destruction requires temperatures above 1,200 degrees Fahrenheit. Once PCBs are incorporated into fish, animals, and other foodstuffs, they cannot be eliminated by processing.

About 1.4 billion pounds of PCBs were produced in the United States between 1929 and 1977. Although the United States production of PCBs has ceased, it is estimated that 450 million pounds of PCBs exist in the environment, and 750 million pounds of PCBs are still in industrial and domestic use.

Some people, however, feel that no level of contamination is acceptable. The FDA regulates the use of PCBs in equipment and machinery employed in food and animal feed production and food packaging and storage materials. Regulations are necessary since there have been cases of PCB contamination of various foodstuffs from herbicides, paper wrappers, and cartons, and transfer fluid leakage.

PCBs pose a great threat to freshwater fish because it is extremely difficult to eliminate the PCBs already present in waterways. PCBs also tend to accumulate in the fatty tissue and flesh of fish and other animals that eat them. Freshwater fish most affected with PCBs include: coho and chinook salmon, steelhead trout, striped and small-mouth bass, carp, eel, rockbass, catfish, alewife, and lake trout. Even in the late 1980s, a two-year study funded by FDA revealed that people who eat Lake Michigan fish had more PCBs in their blood than people who do not; however, long-range effects on human health have not been confirmed.

For added information review the activity "Which fish can we eat?" in this book.
Websites: FDA homepage – http://www.fda.gov/fdahomepage.html
Catalog of FDA Information For Consumers Publications and Audiovisuals – http://www.fda.gov/opacom/catalog/decemcat.html
US FDA Pesticides and Chemical Contaminants – http://vm.cfsan.fda.gov/~lrd/pestadd.html
FDA Seafood hotline – http://vm.cfsan.fda.gov/~lrd/seafood.html; Phone: 1-800-332-4010 (1-800-FDA-4010)

FDA Public Affairs Specialists in the Midwest Region:
Chicago: FDA, 300 S. Riverside Plaza, Suite 550 – South, Chicago IL 60606; Ph. ((312) 353-5863 (ext. 188).
Detroit: FDA, 1560 East Jefferson Avenue, Detroit, MI 48207 Ph. (313) 226-6260 (ext 149).
Indianapolis: FDA, 101 W. Ohio St., Indianapolis, IN 46204; Ph. (317) 226-6500 (ext. 13).
Minneapolis: FDA, 240 Hennepin Ave., Minneapolis, MN 55401; Ph. (612) 334-4100 (ext. 129).
Milwaukee: FDA, 2675 North Mayfair Road, Suite 200, Milwaukee, WI 53226 1305; Ph. (414) 771-7167

For the most up-to-date information on fish restrictions, contact the Michigan Department of Community Health, Division of Environmental Epidemiology, 1-800-648-6942 (in Michigan), or (517) 335-8350.

OFFICER OF THE NEW YORK DEPARTMENT OF ENVIRONMENTAL CONSERVATION

The Department is responsible for the enforcement of all laws and regulations relating to fishing on Lake Ontario. Its budget for these activities comes from fees for the licenses it issues to commercial and sports fishers. These revenues are also used for stocking fish in many of the waters of New York State. Although the department is part of the executive branch of the state government, it is sensitive to the concerns of state legislators, since they are responsible for approving any increase in the department budget.

The Federal Food and Drug Administration (FDA) has issued maximum standards for PCB content in milk, poultry, eggs, animal feed, and fish. (The PCB level tolerated by the FDA in fish is 2.0 ppm.) Tests have shown that all species of fish in Lake Ontario contain some PCBs; however, only salmon, trout, white bass, striped bass, and channel catfish contain concentrations of PCBs above the 2.0 ppm level. Generally the older and larger the fish, the higher the PCB contamination. Many of the young of the fish species mentioned above have less than the 2.0 ppm level. Also, the department has found that the amount of contamination varies according to the area of the lake in which the fish were caught; only in certain bays do the fish exceed the 2.0 ppm level. The department intends to test Lake Ontario fish monthly for PCB levels.

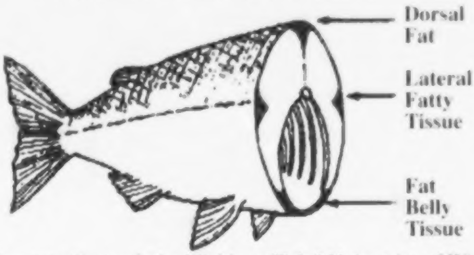
It is important that fishers are advised of the PCB contamination in fish. The Department intends to print a warning on the fishing licenses of the sport fishers. It cautions them to eat no more than one meal per week of contaminated species. Besides advising fishers of the PCB danger, the general public should be protected from eating contaminated fish caught by commercial fishers. Pregnant women and younger children are especially susceptible to the side effects of high PCB concentrations. The Fish Filleting Guide is one effort of the department to inform the public of ways to reduce PCB content of fish.

The New York State Department passed a regulation that became effective before the fishing season opened, which placed a statewide ban on all commercial striped bass fishing. As a result, fishers must turn to other fish species. This legislation has caused impacts on consumption and affected the livelihood of commercial fishers, charter boat operators, and other businesses such as restaurants that rely on this industry as well.

In addition, any regulation enacted by the health department that calls for strict regulations on species or size of fish caught commercially in Lake Ontario will be difficult to enforce. Depending on the amount of additional enforcement needed, the department may not be able to fund it for at least 2 years. The department operates on a fixed budget which is developed and appropriated 2 years ahead of time.

An abbreviated version of a filleting guide is included here from the University of Wisconsin Sea Grant. To obtain the New York Filleting Guide, contact: NYS Dept. of Environmental Conservation, 50 Wolf Road, Albany, NY 12207 Also: Division of Public Affairs and Education – (518)457-0849, and Health Department – 1-800-458-1158, ext. 409 (in New York).
Learn more about New York State Department of Environmental Conservation – http://unix2.nysed.gov/ils/executive/encon/dec007.htm

Cleaning and Trimming
- Remove all of the skin
- Cut away the dark meat on top of fish along the backbone.
- Slice off the fat belly meat along the bottom of the fish.
- Cut awat a V-shaped wedge along the lateral line on each side of whole fish or on skin side of each fillet.



Source: "Eating Lake Michigan Fish," University of Wisconsin Sea Grant Institute, June 1989.

Role: Association for the Protection of the Health of New York Citizens

The Association for the Protection of the Health of New York Citizens is an activist organization. Its members monitor industry for pollution sources. The organization acts as a watchdog over governmental actions that might affect regulation of possible pollution sources and health hazards. It has a small professional staff of two lawyers and one environmental scientist.

The association has engaged in a variety of activities. It will frequently bring lawsuits against polluting industries. It can turn out large numbers of members at hearings that the organization feels could influence policies having an impact upon health and the environment. It sponsors letter-writing campaigns to elected officials when they are considering issues of importance to the association. The staff will write newspaper articles and articles for magazines on issues of importance. They can call on members who are effective speakers to present the association's point of view on health and environmental issues at conferences, public meetings, and on radio and television broadcasts.

The representatives of the association present at this hearing want the obtaining and distribution of fish tightly controlled. They feel that this is the best policy for ensuring that New York citizens are not affected by PCB-contaminated fish. They feel that any effect of tight regulations on the economy of the state would be less than the cost of health care and loss of wage earning potential to those citizens whose health would be affected by the eating of contaminated fish.

For related information see the article: Schmidt, Wayne A. 1989. "Are Great Lakes Fish Safe to Eat?" *National Wildlife*. Vol. 27, No. 5 (August-September): 16 (4).

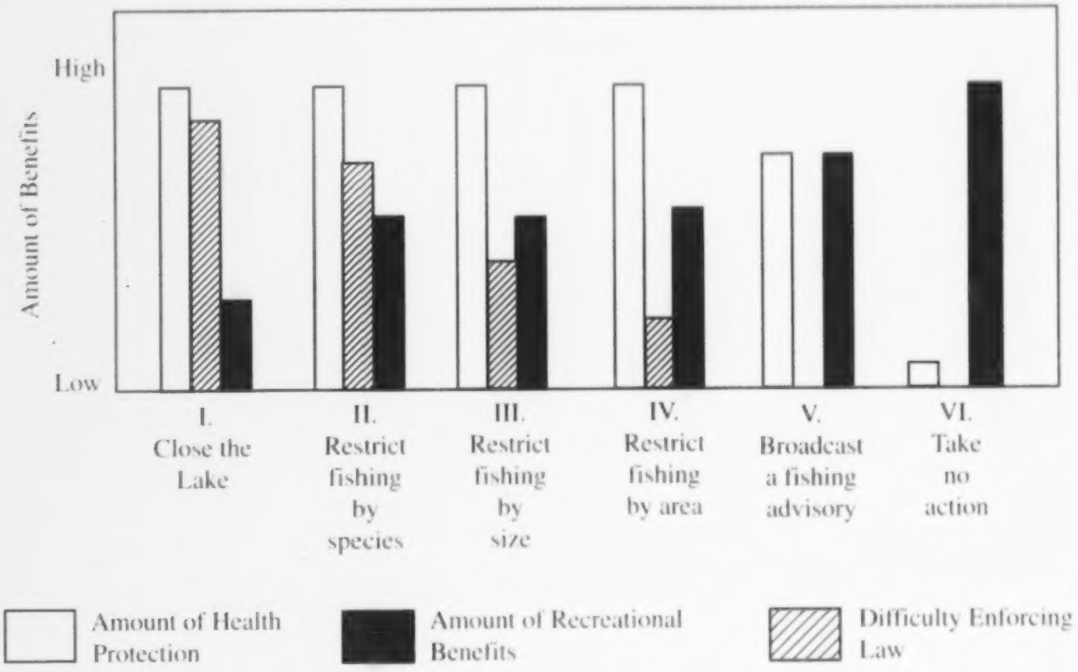
ROLE: ASSOCIATION OF LOCAL, MUNICIPAL, AND STATE PUBLIC OFFICIALS

Membership of this organization includes local and state elected officials. Mayors, county commissioners, and state legislators make up the most powerful groups within the organization. The association has a responsibility first to its membership: to lobby for bills and regulations that the membership agrees best serve their voters and themselves. Because the people they represent have different interests and needs, they are frequently in conflict, making it difficult for the association to develop single, coherent positions on issues. For instance, health interest groups such as the American Cancer Society want benefits for the consumer that provide high health protection. Options I - IV seem to offer the greatest health protection. Business groups dealing in recreation, such as hotel owners, restaurant operators, and marina operators do not want policies that would cut into their business, such as restrictions on fishing. The public officials know how important income from recreation is to New York, and they do not want any policies that would give New York a bad name and thereby discourage people from spending their vacations there. These groups favor *no action* as the best option for recreation needs.

Because they are responsible for law enforcement, public officials realize that any regulations resulting from policies must be enforceable to be effective. Yet they do not want to burden enforcement agencies with programs that will require a great deal of money and additional staff. Options I - III would be difficult to enforce.

With these points in mind, examine the graph below. It shows the relative amount of health protection, ease of law enforcement and recreational benefits to society of each of the policies under consideration.

COMPARISON OF POLICIES



ROLE: THE MARINA OPERATORS ASSOCIATION OF NEW YORK

Marina owners and operators earn their living from recreation activities near Lake Ontario. A big source of income is from the charter boat business. Many anglers cannot afford to own a boat and do not have the experience necessary to safely operate a boat on the lakes, but they can still enjoy the relaxation and challenge of fishing by chartering a boat for a day. Marinas often rent space to charter boat operators. A marina is important to those who own their own boats also. If the owner has no room to store a boat or does not want to tow the boat to the lake every time it is used, the owner will rent a space for the boat at a marina. If fishing is restricted in Lake Ontario, boat owners will take their boats to other lakes where there are no restrictions. There would be many empty marinas on Lake Ontario if this happened, and some would be forced to close. Another major source of income comes from selling tackle and bait to fishers.

Lake Ontario marinas employ many workers and are important to the economy of lake towns. Restricted fishing would hurt marina business and force many to close. Instead, the Department of Health should use marinas as a valuable information source. They are the perfect location for distributing pamphlets and brochures on PCBs. Used this way, they could supply every angler with information on unsafe fish species, proper cooking techniques, and instructions for cleaning fish to reduce PCB content. In this way, the angler could decide, on the basis of impartial information, whether to fish and how to handle the fish once it is caught.

Marina operators are very concerned about the anglers' health – after all, they keep the marinas in business! But restricting fishing would not benefit anyone. Instead, they believe the angler should be allowed to make the decisions that bear on his/her recreation and health.

ROLE: THE SPORTS FISHERS OF NEW YORK

Based on Ohio and National Survey Data

Sports fishers are a very large group of people with influence in the state legislature. Total angler expenditures for the state in 1991 were $867,242,000. There are over 1 million anglers throughout the state, many of whom spend much of their fishing time on Lake Ontario. Overall, anglers spend over $60 million per year on fishing licenses, charter boats, fishing tackle, bait, hotel accommodations, and meals while at Lake Ontario. This money supports many lake-town businesses. The license money helps to stock fish in the lake and supports enforcement of fishing laws on the lake and throughout the state. It is easy to see why sports fishers are a powerful group whose recreational dollars are important to New York State.

Many anglers are business people who like the relaxation and enjoyment that fishing provides. Because of their busy schedules, they do not have a lot of free time to devote to fishing, and they are glad that there are no major restrictions on their fishing. Recreational freedom is important to them. Sports fishers also believe that restrictions on Lake Ontario fishing would violate their freedom of choice for eating fish. Most fishers say they are aware of the danger of PCBs, but they know how to minimize these dangers. Many pamphlets are available that explain which species are affected, which sizes of fish are affected, and how to clean and cook fish to reduce the PCB content. Most anglers feel that this information is sufficient to control PCB problems.

Also, some people do not even eat the fish that they catch! Restrictions would be very unfair to those who fish just for the fun of it.

Find out more information about fishing in the Great Lakes. Start with the Great Lakes Fishery Commission homepage (http://www.glfc.org) and the Great Lakes Sport Fishing Council (http://www.execpc.com/~glsfc).

ROLE: THE NEW YORK ASSOCIATION OF COMMERCIAL FISHERS

(This role is based on information from the fishing industry on the Ohio portion of Lake Erie. Lake Ontario does not have an important commercial fishery.)

Many of the fisheries on Lake Ontario have been owned by one family for many generations. The owners have fished all their lives and are dependent upon the fish for their livelihood. Most have either a grade school or high school education. The fisheries employ many additional people to catch and process the fish for eating. A restriction on commercial fishing would have a severe economic effect upon the owners and their employees. In fact, the fishery on the lake may have to close down completely, causing a great deal of unemployment.

Fisheries are significant contributors to the State's economy. All of the fisheries on the Great Lakes contribute $95 million each year to the United States and Canadian economies. New York would lose millions of dollars if restrictions were placed on commercial fishing.

Businesses such as restaurants and grocery stores depend on commercial fishers to supply them with fresh and processed fish. They want to spend their dollars in New York, instead of buying expensive out-of-state fish. This benefits New York by keeping money in the state, and consumers by providing less expensive fish.

When consumers buy Lake Ontario fish, they are getting a great deal. Lake fish are just as tasty as ocean fish, they cost less than ocean fish, and a fish dinner is a healthy and nutritious meal. The National Marine Fisheries Service in Washington, D.C., reports that a serving of fish has less calories and more protein than an equal size serving of beef or pork. Consumers really benefit when they eat fish. Even though PCBs can accumulate in fish, there are effective ways to prepare fish so that they are safe to eat. Pamphlets are available from the New York Department of Fish and Wildlife that illustrate methods of trimming fat and procedures for cooking that can reduce PCB content 25-64 percent.

Consult the COMCAT Internet site for more information:
"COMCAT contains commercial fish catch data for the Great Lakes from 1971 to the present time. Data include species caught, location, month of take, total catch in pounds, and dollar value. Data are used for economic forecasts, evaluation of fish populations, and stocking calculations" (Great Lakes Commercial Catch Database. [Online] Available http://www.nbs.gov/irm/CaisCOMCAT.html).

REFERENCES USED IN PREPARATION OF THIS ACTIVITY

"Annual Report of the Lake Carriers Association" 1987.

National Survey of Fishing, Hunting and Wildlife-Associated Recreation. State Overview. Issued December 1992. U.S. Department of the Interior, U.S. Fish and Wildlife Service.

"Polychlorinated Biphenyls (PCBs) in Fish and Shellfish; Reduction of Tolerances; Final Decision." *Federal Register*, Vol. 49, No. 100, Tuesday May 22, 1984, Rules and Regulations. See also the *Federal Register*, Vol 44, no. 127, June 29, 1979, p.38330-38340 for an earlier notice regarding the issue.

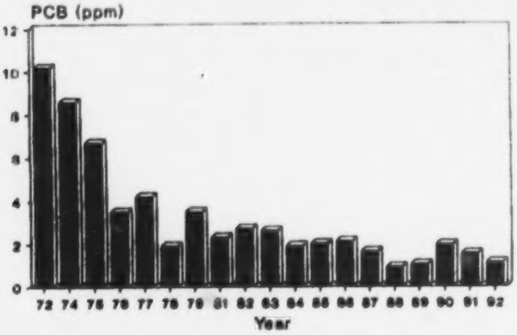
The New York Times, as follows:

Clavin, Thomas."Bluefish Study Stirring Concern on Health." *The New York Times*, Sunday, June 28, 1987.

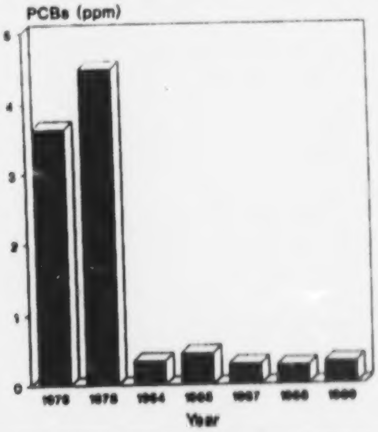
Faber, Harold. "State to Ban All Commercial Striped Bass Fishing." *The New York Times*, Tuesday, April 22, 1986.

Knudson, Thomas J. "With Striped Bass Ban, A Way of Life Is Fading." *The New York Times*, Friday May 9, 1986.

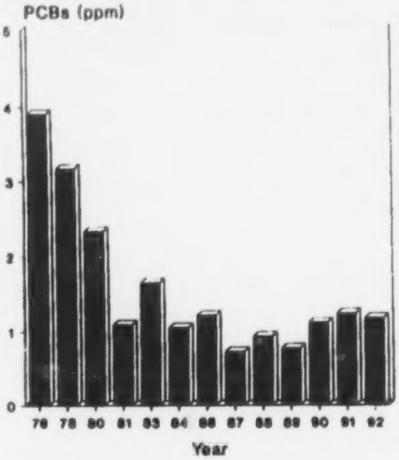
Mean Concentration of PCB in Coho Calmon Collected at the Credit River



Mean Concentration of PCB in Lake Trout from Lake Superior at Peninsula Harbour



Mean Concentration of PCB in Rainbow Trout Collected at the Ganaraska River



Source of Graphs: Cox, C. and J. Ralston. June 1990. *A Reference Manual of Chemical Contaminants in Ontario Sport Fish*. Ontario Ministry of the Environment, Toronto, Ontario. 32 pp. Located from A Strategy for Virtual Elimination of Persistent Toxic Substances. August 1993. Volume 2. Windsor, Ontario: International Joint Commission.

An additional reference about PCBs:

EATING LAKE MICHIGAN FISH

What Are PCBs?

PCBs, polychlorinated biphenyls, are colorless and odorless chemicals that were widely used in electrical equipment and other industrial applications before they were banned in 1976. These man-made chemicals are considered toxic because exposure to small doses is suspected of contributing to a variety of health problems. PCBs do not quickly decompose into less harmful chemicals, so they are extremely persistent in the environment.

Are PCBs Still Entering the Environment?

Yes. Of the 1.4 billion pounds of PCBs produced in this country before 1976, about half has entered the environment via discharges to air, land, and water. Products that contain PCBs are also still being disposed of. The problem is, PCBs remain mobile in the environment, leaching out of landfills into rivers and lakes, and evaporating into the air. Scientific studies have shown that atmospheric fallout accounts for a substantial amount of the PCBs entering the Great Lakes today.

Why Are PCBs a Problem in Lake Michigan Fish?

Most PCBs in the environment end up in rivers, streams, lakes and, ultimately, the oceans. Once there, PCBs enter the food chain and become progressively concentrated from small organisms to large fish and, finally, in people who eat the fish. Many large, fatty fish like lake trout, carp, and chinook salmon have been found to contain PCB concentrations 100,000 to 1 million times greater than the concentrations in surrounding waters. As a result, some fish contain high enough PCB levels that they are considered unsafe for human consumption.

How Long Will PCBs Remain a Problem in Lake Michigan Fish?

Unlike sugar, which is metabolized and passed through an animal's body, most PCBs tend to build up over time in a fish's fat and tissues. The older a fish is, the more it has eaten, the more PCBs it has concentrated in its body. In large older fatty fish, PCBs may remain a problem for at least a decade. Because PCBs become attached to particles in the lake, they eventually settle out and are buried in bottom sediments. However, it takes a long time for PCBs to become permanently buried. As bottom-dwelling organisms feed, they ingest these PCBs and pass them back into the food chain.

Even after all inputs of PCBs into the Great Lakes have stopped, the chemicals still remain in the food chain for years. Several studies are currently under way to determine how long contaminated sediment will continue to contribute PCBs into the aquatic food chain.

What Levels of PCBs Are Considered Safe in Fish?

The U.S. Food and Drug Administration has determined that fish containing PCBs at levels over 2 parts per million (ppm) pose a health risk to people who eat them. One part per million is comparable to one cup of milk out of the total volume of 16 milk trucks. Commercially caught fish containing more than 2 ppm PCBs cannot be sold for human consumption. Based on this standard, the states bordering Lake Michigan have issued health advisories concerning consumption of certain sport-caught fish. The standard is based on the fact that high levels of PCBs have caused cancer in exposed laboratory animals. Medical authorities suspect prolonged exposure to small doses of PCBs can contribute to a variety of human health problems, including developmental problems in children, liver damage and cancer. The federal PCB tolerance level in fish is based on the assessment that the average person, consuming 13 pounds of fish per year, will not accumulate dangerous levels of contaminants over his or her lifetime. As in fish, PCBs accumulate in humans and are not passed out of the body.

What Is the Risk of Eating Great Lakes Fish?

There is controversy over whether PCBs, when consumed at the levels found in Great Lakes fish, actually harm humans. But the longer you live and the more PCBs you ingest, the more PCBs you are likely to concentrate in your body, so state health agencies recommend that you limit your consumption to fish with PCB levels below 2 ppm. Most people today have traces of PCBs in their blood and fatty tissues. Individuals who consume large quantities of fish that contain high PCB levels (such as large chinook salmon, brown or lake trout) from the Great Lakes, especially from Lake Michigan, will have substantially higher intakes of PCBs than the general population. Based on conservative projections from animal studies, such individuals may face an increased risk of developing cancer. However, it is far more dangerous to smoke cigarettes or not wear a seatbelt than to eat Great Lakes fish. All three of these risks are voluntary and can be minimized by an individual.

Is the Risk Higher in Some People?

Yes. Medical studies indicate the risks of developmental or health problems from PCBs are highest for the developing fetus and nursing infant. A woman who has accumulated high levels of PCBs in her body can transfer large doses of PCBs directly to her fetus while pregnant, and later her infant can receive additional PCBs through her milk. Because they are smaller, children can receive a higher body-dose of PCBs than adults eating the same fish. Thus, if they eat *any* sport fish, young children (especially girls) and women of childbearing age should eat only those with the lowest levels of contaminants (Group 1 fish in Wisconsin's health advisory). Men, and women past their childbearing years or who plan to have no children, face a comparatively lower health risk if they avoid eating highly contaminated (Group 3) fish (based on the average consumption of 13 pounds of fish a year).

What Kinds of Fish Are Most Contaminated?

It is the larger older fish, which have eaten more food (especially oily alewives), that have the highest levels of PCBs. Lake trout can live in Lake Michigan for 10 years, so they generally contain more PCBs than chinook salmon, which only live in the lake for 3 to 4 years. Coho salmon, which are in the lake only 2 or 3 years, contain even lower levels than chinook salmon. However, the amount of PCBs in two similar sized fish of the same species, caught in the same area of the lake, can vary greatly. Recent samples indicate these Great Lakes sport fish are likely to contain PCB levels higher than 2 ppm and, according to fish consumption advisories, should not be eaten:

- Lake trout over 23 inches.
- Brown trout over 23 inches.
- Chinook salmon over 32 inches.

Furthermore, children and women of childbearing age are advised to avoid eating:

- Lake trout over 20 inches.
- Chinook salmon over 21 inches.
- Coho salmon over 26 inches.
- All brown trout.

Many other species of fish in Green Bay contain PCB levels higher than those found in Lake Michigan fish. For information on these fish, contact the nearest Wisconsin Department of Natural Resources office.

Are PCB Levels in Fish Declining?

Yes. PCB levels in most Lake Michigan fish appear to have declined dramatically in the last 10 years, and this trend seems to be continuing. However, PCBs remain a problem in lake trout, due to their size, age and alewife diet. The levels of PCBs in fillets taken from large lake trout formerly tested around 25 ppm PCBs. Today, they test out at 4-8 ppm. PCB levels in larger chinook salmon have dropped, but they remain in the 2-3 ppm range. The states around Lake Michigan have stepped up their sampling programs and pooled their information to determine the PCB levels more accurately.

Due to the vast amount of PCB-contaminated sediment in Green Bay, however, declines in PCBs in fish tissue there have not been as evident over the past few years.

Are Small Fish Less Contaminated?

Yes. Small fish and fish that do not feed on alewives contain lower levels of PCBs because they have not lived as long and ingested enough PCBs to have accumulated high levels of the chemical. Lake trout smaller than 23 inches, coho salmon and rainbow trout generally have PCB levels below 2 ppm. Perch and smelt contain PCB levels lower than any other Lake Michigan sport fish.

Can Cleaning Fish Reduce PCB Levels?

Yes, but not always enough to bring PCB levels below 2 ppm. Great Lakes fish consumption advisories are based on an analysis of fish fillets, including the skin and certain fatty areas. You can significantly reduce the level of PCBs in fish by properly cleaning, trimming and skinning your catch. It is important to trim all the fat from four key areas: the belly flap, lateral line, along the backbone, and adjacent to the skin. Tests on chinook salmon from Lake Michigan show that proper removal of the skin and fat from these four key areas reduced PCB levels by more than 50 percent. Similar tests on lake trout show that PCB levels can be reduced by more than 30 percent.

Can Cooking Fish Reduce PCB Levels?

Yes. While cooking does not destroy PCBs, the heat from cooking melts the fat in the fish, thus removing some of these contaminants. It is not advisable to deepfry your Great Lakes catch. It is best to broil or bake trimmed, skinned fish on an elevated rack so any additional fat melted out of the fish drops off. Do not use the drippings for sauces: Dump the drippings in the garbage. If you boil or poach your fish, discard the fish broth. Studies on smoked fish have shown that while some oil leaves the fillets, a significant amount of moisture also leaves, so smoking does not substantially reduce PCB levels.

For more infonnation, contact your local University of Wisconsin Sea Grant Advisory Services office or the University of Wisconsin Sea Grant Institute, 1800 University Ave. Madison, WI 53705-4094. Information is also available from local Wisconsin Department of Natural Resources offices and the Wisconsin Department of Health and Social Services in Madison. (WIS-SG-88-154)

[NOTE: While this fact sheet addresses fish contamination issues specific to Lake Michigan, the issues are similar throughout the Great Lakes. Each Sea Grant program in the region produces annual updates on the fish advisories for its lakes, and anglers get similar information when they purchase fishing licenses.]

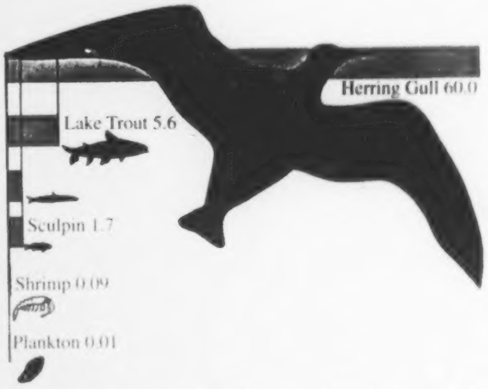
How do toxins move through the food chain?

Many of the chemicals we use in our homes and on our farms are poisonous or toxic. These chemicals include insecticides, weed killers, and other pesticides, oil-based paints, nail polish remover, silver polish, motor oil, and many cleaning products. Our factories also produce many toxic chemicals as wastes in manufacturing. What happens when these chemicals enter the environment? How do they affect the plants and animals in a food chain? How are birds in the Great Lakes affected by these toxins?

Many toxic chemicals bioaccumulate. This means that they collect in the body of the organism that ingests them. PCBs for instance, remain in the fatty tissue of organisms that consume them. If a fish lives in contaminated waters, it eats other organisms that contain the toxins, so that the PCBs collect in its fatty tissue. The concentration of PCBs in the fish's body becomes much higher than in the water in which it lives. The longer a fish lives, the more toxins it will accumulate. If a bird eats several fish that are contaminated with PCBs, then that bird "collects" the toxins from each of those fish. In this manner, the toxin is passed up the food chain at higher and higher levels of concentration. This activity will demonstrate that phenomenon.

Birds that eat fish are near the top of the aquatic food chain and for this reason sometimes have health problems caused by toxic chemicals. The bald eagle, for instance, became endangered when DDT, a pesticide used to kill insects, entered the water system and eventually reached them through the food chain, causing the birds to lay very thin-shelled eggs. These eggs were easily crushed by the parent bird when it tried to incubate them. Other chemicals found in the Great Lakes affect other species of birds. Cormorant chicks, for instance, are sometimes born with misshapen beaks that keep them from eating.

Figure 1. Biomagnification of PCBs in the Lake Ontario food web, 1982.*
PCBs shown in parts per million.



*Source: Environment Canada, *Toxic Chemicals in the Great Lakes and Associated Effects: Synopsis*, Department of Fisheries and Oceans, Health and Welfare Canada, Toronto, Ontario, 1991. Figure obtained from Deposition of Air Pollutants to the Great Waters, First Report to Congress, U.S.E.P.A., May 1994, EPA-453/R-93-055.

OBJECTIVE

After you complete this activity you should be able to give an example of the basic principle of bioaccumulation.

Materials

For a class of 20-30 students:

- A large open area (inside or outside).
- At least 200 small squares of paper.
- One paper lunch bag for each student.
- Short pieces of three colors of yarn (to identify which of the three groups each student belongs to). These will be tied onto each student's wrist.

Source

OEAGLS EP-30, *Eating Like a Bird* Activity B by Chris Brothers and Rosanne W. Fortner. Based on a Project WILD lesson.

Earth Systems Understanding

This activity focuses on ESU 4 pertaining to interactions.

Pre-lab

Before the game, mark about 1/3 of the paper squares with an X. Fold all the papers in half so they all appear to be identical. The marked papers represent contaminated algae.

The students will be in three unequal size groups. To determine the appropriate group size, divide the lunch bags in half to form two groups of equal size. From one of these two groups, separate out one-third of the bags to form a third group of bags. If there are 30 students, you should have about 15 bags in the largest group (*Daphnia*), 10 in the second group (sunfish), and 5 in the smallest group (cormorants). The appropriate group name could be written on each bag to help avoid confusion.

Teacher's Notes

At the beginning of the activity, each student should get one bag and a piece of yarn to indicate membership with a specific group.

B. Allow about 30 seconds for the *Daphnia* to feed before sending the sunfish into the game and about 30 seconds for the sunfish to feed before sending in the cormorants. Let the cormorants feed about 1 minute before ending the game. You will need to adjust these times depending on how quickly students gather food and catch each other.

It is very important that each group remember who or what they "feed" on:

- *Daphnia* eat Algae
- Sunfish eat *Daphnia*
- Cormorants eat sunfish

PROCEDURE

A. In this game you will first play the part of a *Daphnia* (water flea), sunfish, or cormorant (a bird that feeds on fish). The *Daphnia* will feed on paper square "algae," the sunfish will feed on the *Daphnia*, and the cormorants will feed on the sunfish. Since this is a tag game, you will be trying to get enough food into your lunch bag "stomach" to survive without being eaten yourself. *Daphnia* can only gather algae, the sunfish may only catch *Daphnia*, and the cormorants may only catch sunfish. Each organism in the game will be identified by a different color piece of yarn.

B. Decide where the boundaries of the game will be. Your teacher will scatter the paper "algae" over the ground within these boundaries. This algae is the *Daphnia*'s food source. When the signal is given, the *Daphnia* can start "feeding" by gathering as many paper squares as they can and putting the "food" into their "stomachs."

C. Once the *Daphnia* have had some time to feed, your teacher will send in the sunfish to start feeding on the *Daphnia*. The sunfish should try to tag the *Daphnia*. When a *Daphnia* has been tagged, it must give its stomach lunch bag including all the paper algae collected to the sunfish. Tagged *Daphnia* are out of the game and must go to the sidelines.

D. Once the sunfish have had some time to feed, your teacher will send in the cormorants to start feeding on the sunfish. When sunfish are caught, they must give their stomachs with all the papers they have collected to the cormorant who will put it into his or her stomach. The sunfish is then out of the game and must go to the sidelines. The other sunfish should continue to catch *Daphnia* while avoiding the cormorants.

E. At the end of the game, gather with the rest of your class to discuss the results. Find out how many of each group were "eaten" and how many escaped. Have those who escaped empty their stomachs and count the number of contaminated algae papers they collected. The contaminated pieces are marked with an X. Use the *Effects of Toxin Accumulation* chart to determine how many of each group will "die" because of the amount of poison they have eaten and how many will not be able to reproduce successfully. Discuss which organism has the greatest number of contaminated algae pieces and why this is so.

EFFECTS OF TOXIN ACCUMULATION

Organism	Number of Toxic Algae Papers	Status
Daphnia	Less than 3 3-4 More than 4	Survives Survives but cannot reproduce Dies
Sunfish	Less than 4 4-6 More than 6	Survives Survives but cannot reproduce Dies
Cormorant	Less than 5 5-8 More than 8	Survives Survives but cannot reproduce Dies

Source: Sea World, Inc. 1996

F. Answer the following questions based on the game and the chart.

1. Did any *Daphnia* survive being eaten by the sunfish? How many of the *Daphnia* survived but were not able to reproduce? How many *Daphnia* died because they accumulated too much poison?
2. Did any sunfish survive being eaten by the cormorants? How many of the sunfish survived but were not able to reproduce? How many sunfish died because they accumulated too much poison?
3. How many of the cormorants survived but were not able to reproduce? How many cormorants died because they accumulated too much poison?
4. What kind of organism collected the most contaminated algae pieces in its stomach? Why did this kind of organism accumulate the most toxins?

Responses to these questions will vary depending on the actual data collected by your class.

The cormorants should have collected the most contaminated algae pieces, because they accumulated all those picked up by the *Daphnia* as well as all those picked up by the sunfish.

In this game, you should have seen an increase in the number of toxic algae papers collected by the organisms at different levels of the food chain. The sunfish should have had more toxic algae papers than the *Daphnia* and the cormorant more than the sunfish. This increase in the amount of toxins found at higher levels in the food chain is called **biomagnification**. In addition, older or bigger individuals have higher levels of toxins in their bodies than younger or smaller ones. This phenomenon is called **bioaccumulation**.

> **"High levels of toxic contaminants in the diet led to severe eggshell thinning during the 1960s and '70s, and a dramatic decline in the cormorant population."**
>
> *- Environment Canada, Great Lakes Fact Sheet. The rise of the Double-crested Cormorant on the Great Lakes: Winning the War Against Contaminants.*

Answers

5. Older animals have been feeding longer and have had more time to accumulate toxins. Larger animals generally need to eat more food, thus they pick up more toxins than animals that consume less food. Older animals are also larger than younger ones of the same species.

6. Animals high in the food chain have accumulated all the toxins picked up by the animals they feed on as well as the toxins accumulated by all the other organisms lower than them in the food chain.

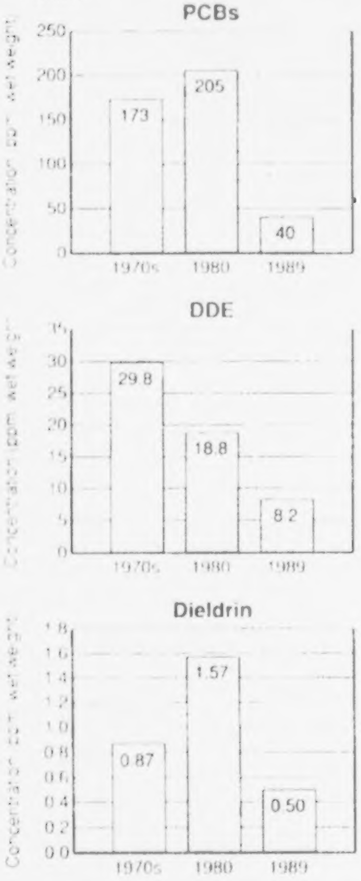


Figure 1. Concentrations of chemicals in eggs of Bald Eagles from the north shore of Lake Erie in the 1970s and 1980s. Source: Ontario Ministry of Natural Resources. Obtained from Environment Canada. A State of the Environment Fact Sheet: *Bringing the Bald Eagle back to Lake Erie*. SOE Fact Sheet No 93-3, 1993.

5. Why do older, bigger animals usually have higher levels of toxins in their bodies than younger or smaller animals?

The toxic chemicals consumed by an animal in its food are stored in its body fat and are in turn passed on to any animal that eats it. For instance, if a sunfish eats 10 *Daphnia* that are each contaminated with 1 molecule of toxin, then the sunfish will gather 10 toxic molecules in its body. Then, if a cormorant or other bird eats 10 of those sunfish, the bird would accumulate 100 toxic molecules.

6. Why do those animals high in the food chain have higher levels of toxins than animals at lower levels of the food chain?

The chemical poisons accumulated by a fish or bird may not kill it directly but may keep it from reproducing or may cause other problems such as tumors, cancer, cross beaks, cataracts, and deformed feet. Scientists can measure the amounts of toxins in the bodies of different animals to get an idea of how many and what kinds of toxic chemicals are found in the Great Lakes. Although the levels of some chemicals are decreasing through clean-up efforts, other toxins are still found at high levels even though their use or production has been banned. This is because these chemicals are very long-lasting; they take a long time to break down. Figure 1 shows the progress that has been made in reducing the concentrations of certain toxic chemicals. Figure 2 indicates a continuing need to monitor bird eggs of different species.

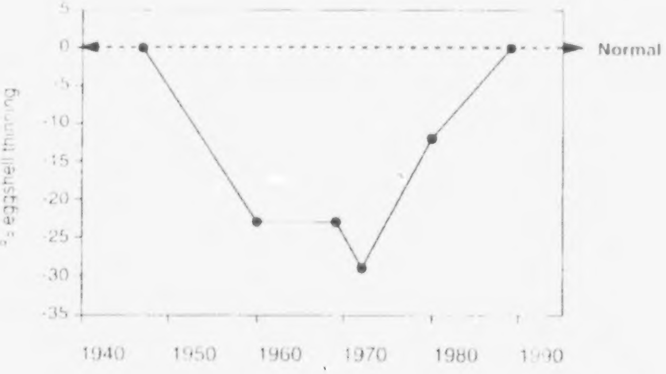


Figure 2. Thinning of Cormorant Eggshells in Ontario.
Data Sources:
1947-69 = Ontario (Anderson and Hickey 1972);
1971-89 = Lakes Ontario & Huron (CWS unpublished).
Obtained from Environment Canada, Great Lakes Fact Sheet. *The rise of the Double-crested Cormorant on the Great Lakes: Winning the War Against Contaminants*, 1995.

CONTAMINANT	SPECIES	EFFECT
DDE, dieldrin, PCB	**Bald eagle**	**Eggshell thinning, embryo mortality; adult mortality**
PCB	**Forster's tern**	**Embryonic mortality, deformities**
Dioxin, PCB, DDT	**Double-crested cormorant**	**Embryo deformities; eggshell thinning**
PCB	**Snapping turtle**	**Embryo abnormalities; embryo mortality**
PCB, dioxin	**Mink and otter**	**Reproductive dysfunction**
PAH	**Brown bullhead**	**Liver and skin tumors**
PCB	**Lake trout**	**Reproductive dysfunction; hatchability and fry mortality**
Dioxin, PCB, DDT	**Herring gull**	**Embryonic mortality; porphyria; thyroid hyperplasia; Vitamin A depletion; deformities; feminization; poor parenting**
PCB	**Human offspring**	**Short-term memory deficits (visual, verbal, quantitative, pictorial); growth retardation; activity retardation**
Lead	**Human offspring**	**Hyperactivity; permanently reduced intelligence; neurobehavioral abnormalities**
Mercury	**Human offspring**	**Learning and motor skill deficits**

Source: Persistent Toxic Substances: Virtually Eliminating Inputs to the Great Lakes. International Joint Commission. July 1991.

IDEAS FOR EXTENSION ACTIVITIES

1. Do research on the safe use and disposal of household chemicals. Which products are toxic? What nontoxic products can be used instead? Does your community have a household toxic chemical collection site or disposal program?

2. Read more about toxic chemicals in the Great Lakes. How do toxins enter the Lakes? What chemicals are of special concern? What is being done to clean up toxins in the Lakes?

[An excellent set of public service announcements designed for television is available at low cost from the Lake Michigan Federation. "It's All Connected..." has recipes for nontoxic alternatives to household cleansers and other products. The announcements make it very clear that everyday activities in the home affect the quality of water in the Great Lakes.]

SUGGESTED READINGS

Ashworth, William. "The Great and Fragile Lakes." *Sierra*. Nov./Dec., 1987, p. 42.

Brown, Michael H. "Toxic Wind." *Discover*. Nov., 1987, p. 42.

Cutler, Daniel S. "Chain Reaction." *Buzzworm: The Environmental Journal*. Autumn, 1989, p. 32.

Edwards, Clayton J. "Toxics in Lake Erie" in *The Great Lake Erie*, Rosanne W. Fortner and Victor J. Mayer, editors. The Ohio State University Research Foundation, 1993, p. 136.

Lipske, Mike. "Danger: Are You Throwing Poisons into the Trash?" *National Wildlife*. July, 1986, p. 21.

Toxic Chemicals in the Great Lakes

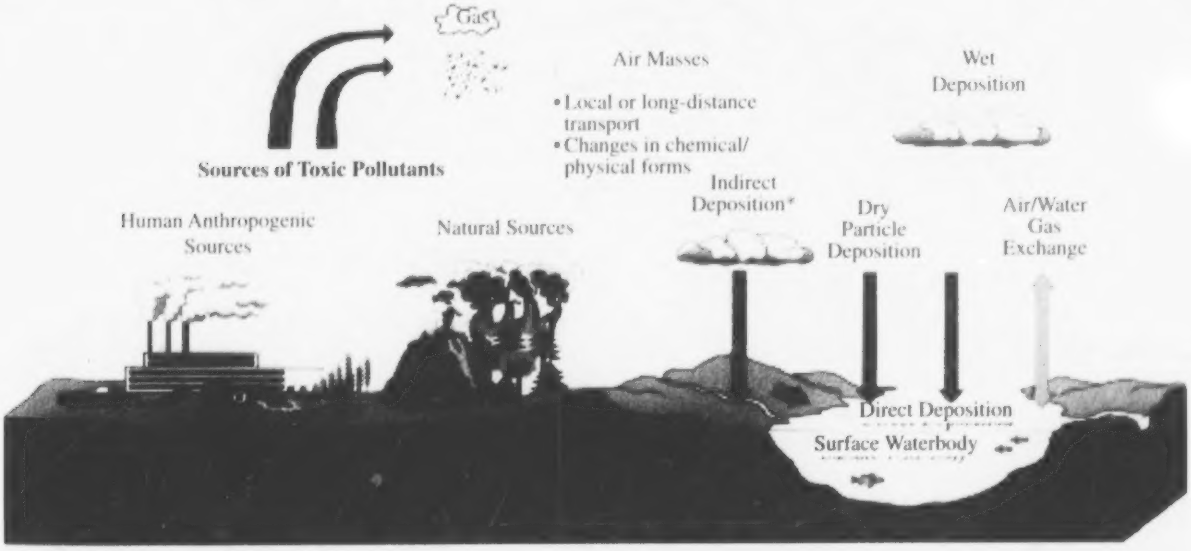
A significant amount of the pollution in the Great Lakes comes from a somewhat unexpected source — the air. According to the Great Lakes Commission (1995), "The Great Lakes, large in surface area and surrounded by numerous urban and industrial centers, are particularly vulnerable to contaminants showered on them from the atmosphere. Atmospheric deposition can account for as much as 90 percent of some toxic loadings to the lakes. Scientists have long surmised that the toxic deposition problem in the Great Lakes is not merely a consequence of local emissions; persistent toxic substances released into the atmosphere thousands of miles away eventually end up in the lakes."

Efforts are now in progress to understand and curb this pollution in order to prevent its deposition into the Great Lakes. A regional *Air Toxics Emissions Inventory* is to document data on point sources and area emissions of 49 toxic air pollutants in the eight Great Lakes states. The source of information about the *Inventory* and related efforts is the Great Lakes Information Network (GLIN) on the Internet at http://www.great-lakes.net

Activity A. How big is the problem of airborne toxins?

When we consider the toxic chemicals that enter the Great Lakes by air, we are actually looking at three types of processes — *release* from a source (which may be natural or anthropogenic), *transport* to other locations, and *deposition* in either wet or dry forms, as shown below (Figure 1).

Figure 1. How does atmospheric deposition occur?
* Indirect deposition is direct deposition to land followed by runoff or seepage through groundwater to a surface waterbody.


Gas
Air Masses
• Local or long-distance transport
• Changes in chemical/ physical forms
Wet Deposition
Sources of Toxic Pollutants
Human Anthropogenic Sources
Natural Sources
Indirect Deposition*
Dry Particle Deposition
Air/Water Gas Exchange
Direct Deposition
Surface Waterbody

(EPA, *Great Waters* p.12)

> **The presence and impact of persistent toxic substances on all sectors of the ecosystem . . . defies boundaries and is not easily resolved through traditional technologies and regulations.**
>
> — IJC, 1992

Source

Modified from "Toxic Chemicals and Global Change" in *Great Lakes Instructional Material for the Changing Earth System (GLIMCES)* by Rosanne W. Fortner - Project Director; Editors – Heidi Miller and Amy Sheaffer. Produced by the Ohio Sea Grant Education Program.

Earth Systems Understandings

This activity focuses on ESU 2 (impact of human activity), 3 (scientific thinking and technology), and 5 (change through time). Understandings 4 and 7 are addressed in the extensions. Refer to the appendix of this book for a full description of each understanding.

Materials

(per team of 4-5 students)
- Copy of Charts 1-3.
- Graph paper.
- A range of supplies for constructing a model of air pollution detection (such as – small electric fan).
  - 2 9x13" cake pans.
  - Source of water, particle source such as dusty erasers or powdered drink mix.
  - Wet deposition source such as water with food coloring in it.
  - Contact paper, filter paper.
  - Other items that might be useful in creating, transporting, collecting, and measuring airborne pollution).

The deposition itself is considered nonpoint pollution because of its diffuse nature. However, it comes from some sources that are identifiable: *point* sources, such as factories or incinerators; *mobile* sources like cars and trucks; and *area* nonpoint sources that are the combined output of sources in a geographic area, like the dry cleaners, gas stations, and other small businesses of a community.

Of their RELEASE -> TRANSPORT -> DEPOSITION to the lakes, the release of the toxic substances is really the only process humans can control on a large scale. Developing different ways to manufacture products for people's lives may reduce the amount of toxic materials entering the environment, yet some byproducts are still likely to be produced. This activity is a series of questions to be answered with existing datasets and creative application of ideas. It invites students to explore the sources that release the toxic substances and possible methods by which the toxins can be transported and deposited.

OBJECTIVES

Upon completion of this activity, students will be able to:

- Describe the types and values of information available from the USEPA's Toxic Release Inventory and Great Waters Program.
- Analyze the trends of toxic releases by air for the Great Lakes states.
- Design a method for demonstrating and detecting the amount of airborne pollution likely to reach points at varying distances from a source.

PROCEDURE

1. **What are the sources of Great Waters "Pollutants of Concern"?**

   To answer this question, students examine Chart 1, which lists selected pollutants that are known to be deposited by air in the areas shown on the map, including coastal areas, but especially the Great Lakes, Chesapeake Bay, and Lake Champlain. All of the pollutants are toxic, they are persistent in the environment, and they have the potential to bioaccumulate through the food chain. To simplify the amount of information, teams of students could choose two pollutant types to follow through the activities, but they should also pay attention to the entire range of pollutants, sources, and effects.

Discuss with the class that some of the pollutants are no longer produced or available in the Great Lakes region, but transport by air still makes them a pollutant here.

2. **What local sources are contributors to Pollutants of Concern to the Great Waters?**

   As they examine the column on "Sources of Air Emissions," students should identify local sources that fit the descriptions given. This should be discussed in light of the important contributions the sources are making to quality of life and standard of living in the community, as well as environmental impact.

   Students should also consult official documents rather than simply speculating on emission sources. The EPA's Toxic Release Inventory is available online from RTK NET (the Right to Know Network) and through CD-ROMs available in local government environment offices. It can be searched by zip code to determine if air toxins are being released (and reported) by the local sources suspected. Reporting such releases is a responsible thing for industry to do; it makes the polluters and the public aware of the impacts of doing business and alerts them all to the need for cleaner lifestyles. However, such groups as farmers using insecticides, as well as people driving motor vehicles producing lead, nitrogen, and POMs, do not have to report!

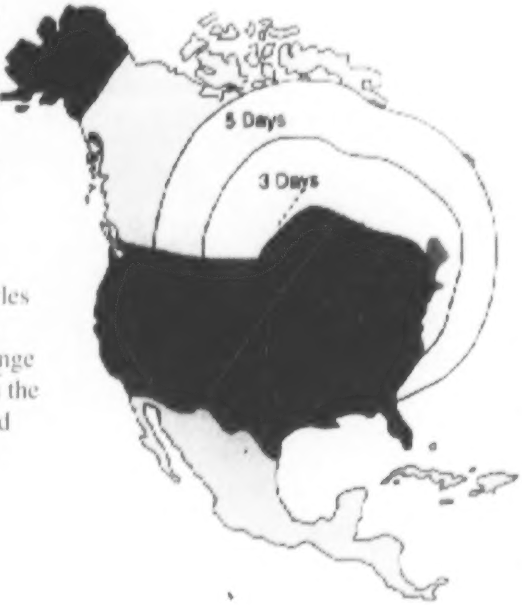
Notes

RTK NET has an Internet connection at http://rtknet.org, but complete records are available only through a long-distance modem call to (202)234-8570. Contact them by voice phone at (202)234-8494 for alternatives or e-mail: Admin@RTK.NET. Also e-mail: info@RTK.NET for additional information and include the word RTK.NET in your message.

3. **What distant sources are important contributors of pollutants?**

   According to the EPA, the Great Lakes "Airshed" is a very large one. Even cleaning up local sources would not prevent air toxins from entering the Great Lakes.

   a. Students should discuss how lifestyles and social conditions (cooperation, economics, etc.) would have to change in order to make desired changes in the environment. What are the costs and benefits of making these changes?



The Great Lakes "Airshed" Bands indicate the approximate number of days required for airborne contaminants to be transported to the Great Lakes basin. (EPA, *Great Waters Index*, p. 10)

Chart 1. Selected Pollutants of Concern in the Great Waters and Sources of Air Emissions (EPA, *Great Waters* 1994).

Pollutant	Examples of Use	Sources of Air Emissions
Cadmium	Used in metals production processes, batteries, and solder.	Fossil fuel and municipal waste combustion; aluminium, iron, and steel production; cadmium, copper, lead, and zinc smelting; battery manufacturing, hazardous waste, and sewage incineration; petroleum refining; lime manufacturing; soil-derived dust; volcanoes.
Chlordane	Insecticide used widely in 1970-80s. All U.S. uses except termite control canceled in 1978, use for termite control voluntarily suspended in 1988. Use of existing stocks permitted.	Insecticide application, volatilization from soils, water, and treated building foundations due to past insecticide application; suspension of eroded soil particles.
DDT / DDE	Insecticide used widely after introduction in late 1946 until significantly restricted in U.S. in 1972. Still used in other countries. Used in U.S. for agriculture and public health purposes only with special permits.	Insecticide application, volatilization from soils and water due to past insecticide application.
Dieldrin	Insecticide used widely after introduction in late 1940s. Used in U.S. for termite control from 1972 until registration voluntary suspended in 1987.	Insecticide application, volatilization from soils and water due to past insecticide application.
Lindane	Main component of lindane, an insecticide used on food crops and forests, and to control lice and scabies in livestock and humans. Currently used primarily in China, India, and Mexico. U.S. production stopped in 1977; however, many uses are still registered, but are expected to be voluntarily canceled in the future.	Insecticide application, volatilization from soils and water due to past insecticide application.
Lead and Compounds	Used in gasoline and paint additives, storage batteries, solder, and ammunition. Released from many combustion and manufacturing processes and from motor vehicles. Use in paint additives restricted in U.S. in 1971. U.S. restrictions on use in gasoline additives began in 1973 and have continued through the present, with a major use reduction in the mid-1980s.	Fossil fuel combustion; aluminium, iron, and steel production; lead smelting; ferroalloys production; battery manufacturing; hazardous waste and sewage sludge incineration; municipal waste combustion; petroleum refining, lime manufacturing; cement manufacturing; chlorine and caustic soda manufacturing; pulp and paper production; combustion of waste oil; paint application; motor vehicles; forest fires; eroded soil particles, volcanoes.
Mercury and Compounds	Used in thermometers, electrical equipment (such as batteries and switching equipment), and industrial control instruments. Released from many combustion, manufacturing, and natural processes. Banned as paint additive in U.S., for interior paint (1990) and for exterior paint (1991).	Fossil fuel combustion, copper and lead smelting; hazardous waste, municipal waste, medical waste, and sewage sludge incineration; lime manufacturing; cement manufacturing; chlorine and caustic soda manufacturing; paint application; suspension of eroded soil particles, evasion from soils and water; volcanoes.
Polychlorinated biphenyls (PCBs)	Industrial chemicals used as coolants and lubricants and in electrical equipment (transformers and capacitors). In the U.S., manufacture stopped in 1977, and uses were significantly restricted in 1979. Still used for some purposes because of stability and heat resistance, and still present in certain electrical equipment used throughout U.S.	Incineration and improper disposal of PCB-contaminated waste; disposal of waste oil; malfunction of PCB-containing transformers and capacitors, electrical equipment manufacturing; pulp and paper production; volatilization from soils and water; municipal solid waste incineration and unregulated combustion.
Polycyclic organic matter (POM)	Naturally occurring substances that are byproducts of the incomplete combustion of fossil fuels and plant and animal biomass (e.g., forest fires). Also, byproducts from steel and coke production and waste incineration.	Combustion of plant and animal biomass, fossil fuels and municipal waste; petroleum refining; steel and aluminium production; coke production and byproduct recovery; creosote production and wood preserving; surface coating of autos and light duty trucks; asphalt processing; dry cleaning (petroleum solvent); forest fires.
2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD)	Byproduct of combustion or organic material containing chlorine and of chlorine bleaching in pulp and paper manufacturing. Also a contaminant in some pesticides.	Hazardous, including sewage sludge incineration; municipal waste combustion; combustion of fossil fuels and organic materials containing chlorine; byproduct of various metals recovery processes, copper smelting; accidental fires of treated wood products and PCB-containing transformers and capacitors; improper disposal of certain chlorinated wastes; pesticide production, application, and spills; pulp and paper production; volatilization from, and erosion of, dust from landfill sites; forest fires.
Toxaphene	Insecticide used widely on cotton in the southern U.S. until the late 1970s. Most U.S. uses banned in 1982; remaining uses canceled in 1987.	Insecticide application; volatilization from soils and water due to past insecticide application.

Chart 2. Toxic Releases by Air in Great Lakes States, 1990-93. (RTK NET)

Year	State	TRI pounds from stack air	TRI pounds from fugitive air	Total air toxins
1990	IL	57391103	33145881	90536984
1991	IL	55129856	28337929	83467785
1992	IL	50520449	23418974	73939423
1993	IL	43967230	19043824	63011054
Total	IL	207008638	103946608	310955246
1990	IN	67652416	41595852	109248268
1991	IN	59580387	33550843	93131230
1992	IN	58382077	26660384	85042461
1993	IN	53339189	23536681	76875870
Total	IN	238954069	125343760	364297829
1990	MI	61885749	22287721	84173470
1991	MI	53585439	18770944	72356383
1992	MI	50908819	16622228	67531047
1993	MI	51134898	16726566	67861464
Total	MI	217514905	74407459	291922364
1990	MN	42927365	7965081	50892446
1991	MN	32072713	7462350	39535063
1992	MN	23962351	5800445	29762796
1993	MN	17037541	5301484	22339025
Total	MN	115999970	26529360	142529330
1990	NY	51509864	23994992	75504856
1991	NY	43808425	17563959	61372384
1992	NY	39044653	16456900	55501553
1993	NY	30929618	13925366	44854984
Total	NY	165292560	71941217	237233777
1990	OH	82964283	37305207	120269490
1991	OH	72698854	33937499	106636395
1992	OH	65059157	28732506	93791663
1993	OH	57654861	26942846	84597707
Total	OH	278377155	126918058	405295213
1990	PA	43977773	34132223	78109996
1991	PA	39778738	28543068	68321806
1992	PA	37502293	25724047	63226340
1993	PA	32019747	20051830	52071577
Total	PA	153278551	108451168	261729719
1990	WI	33504530	10821515	44326045
1991	WI	29188553	8359246	37547799
1992	WI	29399800	7692449	37092249
1993	WI	26043982	7203245	33247227
Total	WI	118136865	34076455	152213320

The Toxic Release Inventory (TRI) is an inventory of the types and quantities of toxic chemicals released by manufacturing facilities. Data are collected from reports to the EPA.

Stack air emissions occur through confined air streams such as stacks, vents, ducts, or pipes. Fugitive air emissions are not released through a confined stream. They include equipment leaks, evaporative losses, and ventilation releases.

b. Trends show decreasing amounts of toxic releases by air. Total amounts differ greatly by state.

c. Answers will vary and can be checked on RTK NET or through atlases.

b. Look at Chart 2, with its pounds of toxic releases by air by state. Assign teams to analyze the data for different states, graphing the trends in air pollution emissions, and then comparing the total amounts across states.

c. Compare the population of the assigned state, and other demographic and economic indicators, with the amount of toxic releases reported. Do the amounts of release seem to be related to particular factors within the states?

4. **What are the potential human health and wildlife effects associated with Pollutants of Concern?**

a. Teams examine the data in Chart 3a and 3b. Remember that the effects listed are for the total pollutant present, not just the air-carried component.

b. Given the contributions of the pollution sources to quality of life and/or standard of living, is there enough evidence here to demand that the sources be eliminated?

4b. Discussion should focus on costs and benefits of the sources.

Chart 3a. Health Effects in Wildlife in the Great Lakes Basin.

Species	Reproductive effects	Eggshell thinning	Generational effects	Deformities	Organ damage	Behavioral changes	Hormonal changes	Metabolic changes, wasting	Immune suppression	Tumors
Bald eagle	●	●	●	●		●		●		
Beluga whale	●			●	●		●		●	●
Black-crowned night heron	●	●		●						
Brown bullhead			●	●			●		●	●
Caspian tern	●		●	●		●		●		
Chinook-coho salmon	●				●		●			●
Common tern	●				●	●		●	●	
Double-crested cormorant	●	●	●	●	●	●		●		
Forster's tern	●		●	●	●	●		●		
Herring gull	●	●	●	●	●	●	●	●	●	
Lake trout	●		●		●	●		●		
Mink	●		●		●			●		
Osprey	●	●								
Ring-billed gull	●			●				●	●	
Snapping turtle	●	●	●	●	●			●		
White sucker	●		●				●		●	●

Chart 3a illustrates the variety of health effects observed in wildlife in the Great Lakes Basin. Blank cells do not necessarily mean there is no effect on wildlife, only that research has not been performed on the species.
(Modified from Hilleman, 1993, Chemical and Engineering News.*)*

Note: Effects listed have been in scientific literature published during the past decade.

Chart 3b. Potential Human Health Effects Associated with Pollutants of Concern

Pollutant	Cancer	Reproductive/ Restrictions	Neurological Behavioral	Immunological	Endocrine	Other Noncancer
Cadmium and compounds	Probable	●	●	●		Respiratory and kidney toxicity
Chlordane	Probable	●	●	●	●	Liver toxicity
DDT/DDE	Probable	●	●	●	●	Liver toxicity
Deildrin	Probable	●	●	●		Liver toxicity
Lindane	Probable	● (gamma-HCH)	●	●		Kidney and liver toxicity
Lead and compounds	Probable	●	●	●	●	Kidney toxicity
Mercury and compounds		●	●	●		Kidney toxicity
PCBs	Probable	●	●	●	●	Liver toxicity
Polycyclic organic matter	Probable	●		●		Blood cell toxicity
2,3,7,8-TCDD	Probable	●	●	●	●	Integument toxicity
Toxaphene	Probable	●	●	●	●	Cardiovascular effects; liver toxicity

5. **To what extent does air transport contribute to overall pollution in the Great Lakes?**

An example of the approximate amount of PCBs in Lake Superior from various sources is shown in Figure 2. The numbers tell how much of the pollutant is in different locations (atmosphere, water, sediment).

a. Does it appear that the atmosphere is contributing the greatest amount of the PCBs directly?

b. Not all lakes are as subject to contamination by air (Figure 3). Examine the implications of the percentages in this figure. How important are the following in determining the percentage of pollutants entering by air transport?
- The upstream lake
- The surface area of the lake
- Geographic proximity to pollutant sources

5a. Most are entering the water from "recycling," or resuspension of formerly settled or buried material. Of the direct sources of input, however, the atmospheric component is greater than that of the river inflow. Case studies such as this demonstrate that atmospheric deposition may be an important contributor of toxic chemicals.

5b. All are extremely important influences.

Figure 2. Mass Balance of PCBs in Lake Superior.
Numbers represented are approximations. (EPA, *Great Waters* p. 49)

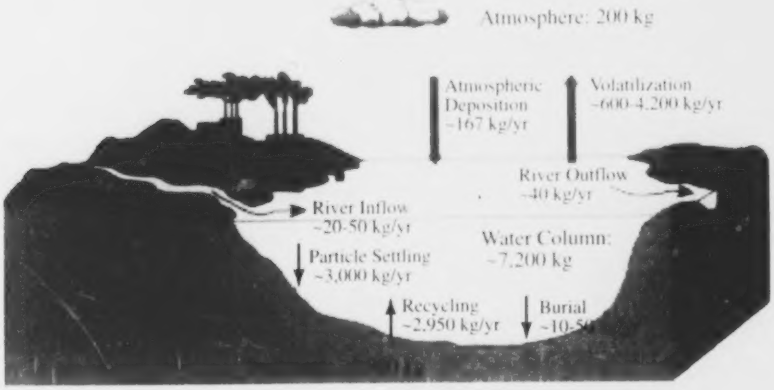
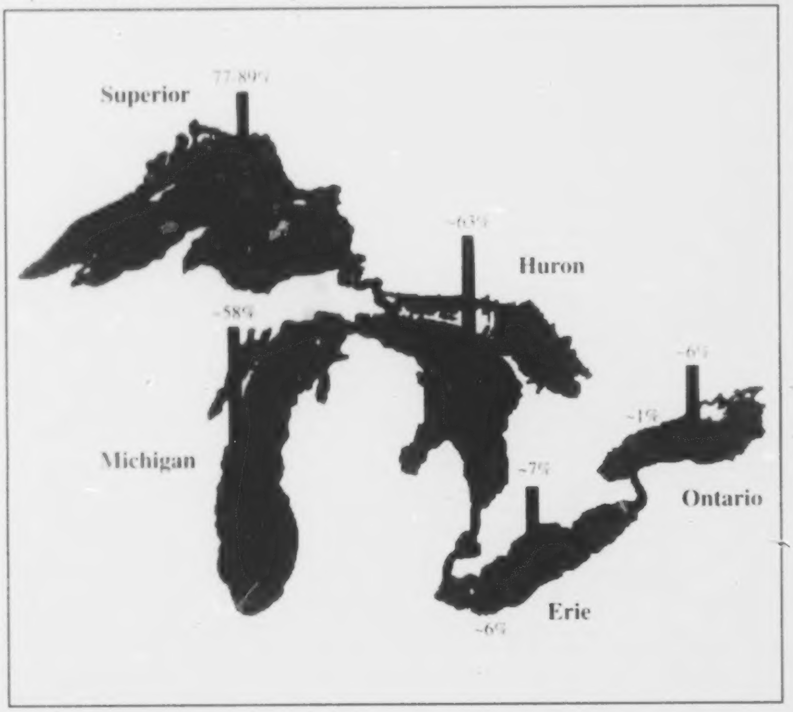

Atmosphere: 200 kg
Atmospheric Deposition ~167 kg/yr
Volatilization ~600-4,200 kg/yr
River Outflow ~40 kg/yr
River Inflow ~20-50 kg/yr
Water Column: ~7,200 kg
Particle Settling ~3,000 kg/yr
Recycling ~2,950 kg/yr
Burial ~10-5

Figure 3. Atmospheric Loading of PCBs to the Great Lakes.
Arrows and flow depict pollution that deposits from the atmosphere directly to water surfaces and travels through the Great Lakes system. The percentages reflect the amount of such pollution compared to that from all other routes. For example, approximately 63 percent of Lake Huron's PCB loading is from atmospheric deposition to the lake itself, and approximately 15 percent is from atmospheric loading to the upstream lakes. The remainder of Huron's PCB loading is from nonatmospheric sources (approximately 22 percent). (EPA, *Great Waters*, p. 54)


Superior
77-89%
~63%
Huron
~58%
~6%
~1%
Michigan
~7%
Ontario
Erie
~6%

6. **How can we demonstrate and document long-range pollution transport?**

   Within teams, students design a method of testing how far various pollutants can travel by air from a point source. Make available a spray bottle with food coloring in water as a source of wet deposition, or some erasers full of chalk dust, or a blower bottle with powdered drink mix to puff out for dry deposition. The following design rules apply:

   a. Pollutants must be released in a way that carries them AWAY from other students. The pollutant release will be in two or three episodes only (three squirts, eraser pats, etc.).
   b. Pollutants are released in front of a small fan or hair blower mounted for a steady flow of wind.
   c. Deposition should be tracked by distance from the source, with some measures near the source, and others farther away in a meaningful pattern.
   d. It should be possible to demonstrate to others that deposition has occurred in the amounts and places reported. (Evidence should be provided.)
   e. While the question here is pollution over water, it is understood that pollution over any surface constitutes acceptable evidence. (The measure may be how much pollution gets in the water, or how much gets on a paper, etc.)

A sample design might be as follows: Set up three pans with equal amounts of water, at regular distance intervals away from the fan. Pat erasers together three times in front of the blowing fan, and watch which of the pans of water gets dust on top. Filter off the dust to measure how far the pollution traveled and which lake got the most pollution by weight or volume. If powdered drink mix is used, a colorimetric comparison of the waters could be the measure.

REVIEW QUESTIONS

1. Suppose you are a citizen who suspects that a local industry is releasing harmful gases, even though there is no bad odor in the air. What information sources would you consult to find out the types and amounts of emissions the company releases by air? What kinds of information must be reported by those who release toxic emissions? What other pollution sources might be responsible for your local air quality but are exempt from reporting?

Answer to Review Question

1. The EPA has prepared a number of documents to assist citizens using the TRI and other EPCRA (Emergency Planning and Community Right-to-Know Act) data. To request TRI reports and other documents, citizens should call their State Section 313 contact or the toll-free EPCRA Information Hotline at 1-800/535-0202.

   Only manufacturing facilities that have 10 or more full-time employees and meet the established thresholds for manufacturing, processing, or otherwise using listed chemicals must report their releases and transfers. Thresholds for manufacturing are currently 25,000 pounds for each listed chemical. Facilities are required to provide release and transfer estimates for each environmental medium and type of transfer, locations of off-site transfers, and waste treatment methods and efficiencies.

   There are some limitations of the TRI data: 23,000 facilities submit over 82,000 reports each year, yet this captures only a portion of all toxic chemical releases nationwide. Non-manufacturing facilities currently are not required to report (such as mining and electric utilities) and are oftentimes sources of significant releases of toxic chemicals. Many facilities that are required to report either do not file at all, or do not file all of the necessary reports. A company may also use its own estimation techniques if actual measurements are not available, and these techniques are not monitored for accuracy. Although additional information is necessary to assess exposure and risk, TRI data can be used to identify areas of potential concern.

2. The older people you know claim that even 5 years ago the air was not as polluted as it is now. React to this statement on the basis of information available to the public.

3. As an environmental scientist you are hired by a polluting industry to prove to the government environmental agency that even though some toxic chemicals are being released to the air, they are not being deposited to the lakes. Describe how you would monitor the transport and deposition of airborne emissions from the company to check the amount reaching both nearby and distant waters.

EXTENSIONS

1. Develop a concept map showing how gasoline contributes to toxic air pollution but also to quality of life in North America.

2. Make a list of the careers or college majors that would be needed among the people who produce, contribute to, and use the Toxic Release Inventory. What additional careers would be involved with pollution prevention using the information in the Inventory?

REFERENCES

"Toxic air emissions in the Great Lakes region." Special Insert. *Great Lakes Commission Advisor* (Newsletter of the Great Lakes Commission) 8(3):1-2A. May/June 1995.

USEPA. 1994. Two free documents served as information sources for this activity:

Deposition of air pollutants to the great waters. First report to Congress. EPA-453/R-93-055, and

The EPA Great Waters Program: An introduction to the issues and ecosystems. EPA-453/B-94-030.

Limited free copies are available from the producers of the reports: Office of Air Quality Planning and Standards, Pollutant Assessment Branch (MD-13),USEPA, Research Triangle Park, NC 27711. Attention: Great Waters Documents.

Activity B: Where do all the toxins go? (Internal View)

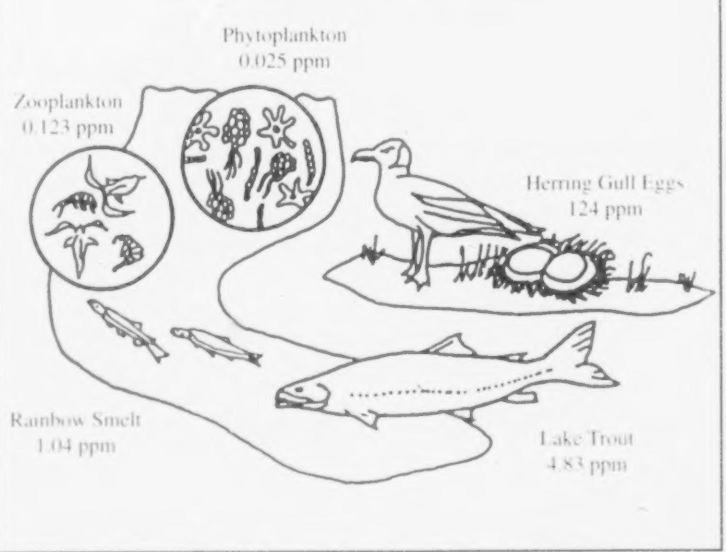
An unfortunate byproduct of the high standard of living enjoyed by developed nations is a heavy reliance on chemicals. Chemicals are used in agriculture and industry and are unintentional byproducts of many human activities. Many of the chemicals that we have become so dependent on are entering our Great Lakes as toxic fallout from the air.

In what ways do chemicals present a problem in the Great Lakes ecosystem? Not very often do we hear about massive kills from chemicals. The effects are much more subtle. Many chemicals enter the food chain at the lower end and accumulate and magnify within organisms throughout the chain. Those carnivores at the top of the food chain, including humans, have the highest levels of these toxins in their bodies. One of the foods that is popular with humans is fish — fatty fish such as trout and salmon accumulate the most toxins through the food chain, and larger fish are the most dangerous. People are warned not to eat fish that exceed a certain length (such as brown trout over 18 inches in Lake Ontario) and to restrict consumption of smaller fish of these species.

The characteristics of a chemical that determine whether or not it will be an environmental hazard are: its toxicity, its persistence, and its affinity for water. Chemicals that have no affinity for water tend to have an affinity for lipids (fats). They combine with the fatty substances in an organism's body, and if persistent, will remain with the organism until it dies or is consumed.

PCBs (polychlorinated biphenyls) are a class of toxic chemicals that appear in many Great Lakes fish. They were frequently used as coolants, especially around electric transformers, because they conduct heat but not electricity. All production of PCBs was stopped in 1976 after it was discovered how toxic they were. However, they do not break down in nature, and many products containing them are still around. As old transformers and other such equipment are discarded, PCBs may leak into the air or water. PCBs then enter the marine food chain and collect in the fatty tissues of fish. PCBs cause carnivores such as cormorants, and scavengers such as gulls, to develop reproductive problems or deformities.

Biomagnification of PCBs



The Great Lakes: An Environmental Atlas and Resource Book. Produced by Environment Canada and U.S. Environmental Protection Agency (1987 and 1995)

In this activity, iodine is used as an example of a fat-soluble compound. The iodine atoms associate themselves with oil (fat) molecules and cause a color change. In the lake environment, chemicals such as DDT and PCBs are fat soluble. They tend to be extracted from the lake water and concentrated in fatty substances in plants and animals. Carnivores, such as fish, eat other organisms that contain the toxins and accumulate the substances in their bodies. High concentrations of these chemicals are found in the belly fat and under the skin of fatty fish such as lake trout, salmon, and chub.

Source

This activity was originated by Michigan Sea Grant in its curriculum activity, "A fish fat phenomenon" (*Great Lakes Fishing in Transition*)

Materials

- Iodine crystals (8 per demonstration)
- Screw-top vial (about 75 ml)
- 20 ml water
- 20 ml vegetable oil
- Ohio Sea Grant Fact Sheet 007: *PCBs: Their history and our health.* (optional)

Earth Systems Understandings

This activity focuses on ESU 2 (stewardship), 3 (science processes), 4 (interactions) and 7 (careers).

Answers

a. The sugar dissolves.
b. The butter would not dissolve; it would stay in lumps.
c. Solubility refers to the ability of one substance to become evenly distributed in another substance.
d. Some of the iodine dissolves — some does not. The water turns light brown.
e. Iodine was extracted into the oil because iodine is more soluble in fat than in water. Since there is no more iodine in the water, the water clears up. The oil layer turns pink, indicating the presence of iodine.
f. Oil
g. The oil represents fat; water represents other bodily fluids (lood, saliva, sweat.)
h. PCBs accumulate in the fat.
i. They can't be washed out because the fats won't dissolve in these fluids.
j. To prepare fish safely, clean all the fat off before cooking, and broil the fish on a rack so that it doesn't cook in its own juices. Note that this method would not remove poison metals such as mercury, because they accumulate in muscle tissue.

OBJECTIVES

When students have completed this activity, they will be able to demonstrate how chemicals accumulate in fish fat, the biopathways of the toxins in the fish's body, and ways to prepare fish to avoid consuming the toxins.

PROCEDURE

1. Introduce the concept of solubility to the students. Ask the following questions:
   a. What happens to a teaspoon of sugar when you put it into a glass of water?
   b. What would happen to a pat of butter if you mixed it into a glass of water?
   c. What is meant by *solubility* ?

2. As a demonstration, put the iodine crystals in the vial with 20 ml of water. Tighten the lid, and allow the students to pass the vial around and shake it.
   d. What happened to the iodine when it was mixed with the water?

3. Open the vial and pour in 20 ml of vegetable oil. Replace the lid, and pass the vial around for more shaking.
   e. What happened when the oil is added? Why?
   f. In which substance is iodine more soluble, water or oil?
   g. What type of bodily substance in an animal does the oil represent? The water?
   h. Where do PCBs accumulate in fish and other animals?
   i. Why can't the PCBs be "washed out" by blood or urine?
   j. If you want to consume fish, but are not sure if it contains PCBs, how would you prepare it to be safe?

4. Distribute the fact sheet on preparing your catch (#007). If possible, have a student who is an experienced angler demonstrate proper fish cleaning. Other students should note where fat is found in the fish's body.

5. Gravid fish (full of eggs) carry most of their toxin load in the eggs. Discuss the implications of this for
   a. Using fish eggs as bait,
   b. Fish that feed on fish eggs, and
   c. The safest time to catch female fish.

6. The use of chemicals has become part of the lifestyle of people living near the Great Lakes.
   d. If all the toxic chemicals were eliminated from the environment, would everyone be pleased? Which professions would suffer without the chemicals? Which professions are impacted now by the presence of toxic chemicals?

EXTENSIONS

1. Investigate the existing and proposed cooperative regulations between the United States and Canada regarding protection of the Great Lakes environment. Do you feel that they are sufficient, or can they be strengthened?

2. Suppose a state or province decided to regulate commercial fishing so that consumers would receive fish with less chance of contamination. Use the activities titled "Which fish can we eat?" and "How should the public health be protected?" to role play the issues that would have to be addressed to strengthen environmental regulations.

Answers

a. Fish eggs used as bait do not have time to be digested. Therefore, they would be relatively harmless to the fish and the angler.
b. Fish that eat fish eggs regularly are exposed to a large amount of toxins. The more they eat, the more they bioaccumulate.
c. The safest time to catch female fish would be when they have just spawned and rid themselves of the toxic load. However, fish flesh sometimes becomes less desirable for food at such a time (it may be softer and have a darker color). If the fish were caught before spawning, while still gravid, the problem might be eliminated. People do not usually eat fish eggs (except for caviar). Fishing at this time could seriously reduce the next year's population of fish.
d. Accept student brainstormed answers and discuss them. Americans depend on toxic chemicals for a variety of things; for instance, the fuel we use to power our vehicles (gasoline) is toxic. Toxic chemicals are components of most paints, plastics, batteries, roofing materials, and pesticides used in farming. They are also used in developing film, dry cleaning, producing paper, making many medical supplies (X-ray film), purifying water for public use, caring for lawns, and a large variety of other things.

Teacher's Note

A recent public health advisory chart that indicates which fish are considered dangerous to eat is located in the activity "Which fish can we eat?" Local information is available wherever fishing licenses are sold.

Activity C: Where do all the toxins go? (External View)

Bioaccumulation is the build-up of chemicals in an organism's body – the longer an organism lives, the more it absorbs. When an older, large lake trout is caught, the concentration of toxins in its body could be a million times that of the original concentrations in the water. *Biomagnification* results when toxins become increasingly concentrated as they pass through the food chain. When a fish feeds on zooplankton, for example, the fish takes up toxins in all of the plankton it eats. In the fish, many of the toxins accumulate in its fatty tissues. When a gull or an eagle feeds on the fish, the bird takes up all of the toxins the fish has accumulated from all the contaminated organisms it has ever eaten. Therefore, the higher up an organism is in the food chain, the greater the amount of toxins it is likely to consume.

Earth Systems Understandings

This activity addresses ESU 2 (stewardship), 3 (science processes), and 4 (interactions).

Materials

Each group will need:

- Copy of Table 1.
- Copy of *human activities and industry* cards (1 page).
- 1 *toxin* card.
- Copy of *food chain cards* (3 pages).
- Copy of *effects of toxin* cards (1 page).
- Scissors.
- Posterboard or butcher paper.
- Glue.

OBJECTIVES

When you have completed this activity, you should be able to describe how bioaccumulation and biomagnification of toxins in the food chain cause health disorders in humans and animals.

PROCEDURE

1. The teacher has prepared cards for the teams. Each of the eight themes (fish, mammals, etc.) is on a different color.
2. Work in groups of three to four people to make a poster. First assemble a reasonable food chain from the cards you have.
3. Each group will be given one toxin card and all of the other cards in order to trace the toxin from its origin to its effects in humans and/or other animals. Table 1 will provide source and effect information on the toxins.
4. Have each group show its food chain poster to the class, and explain the interactions they have linked together.

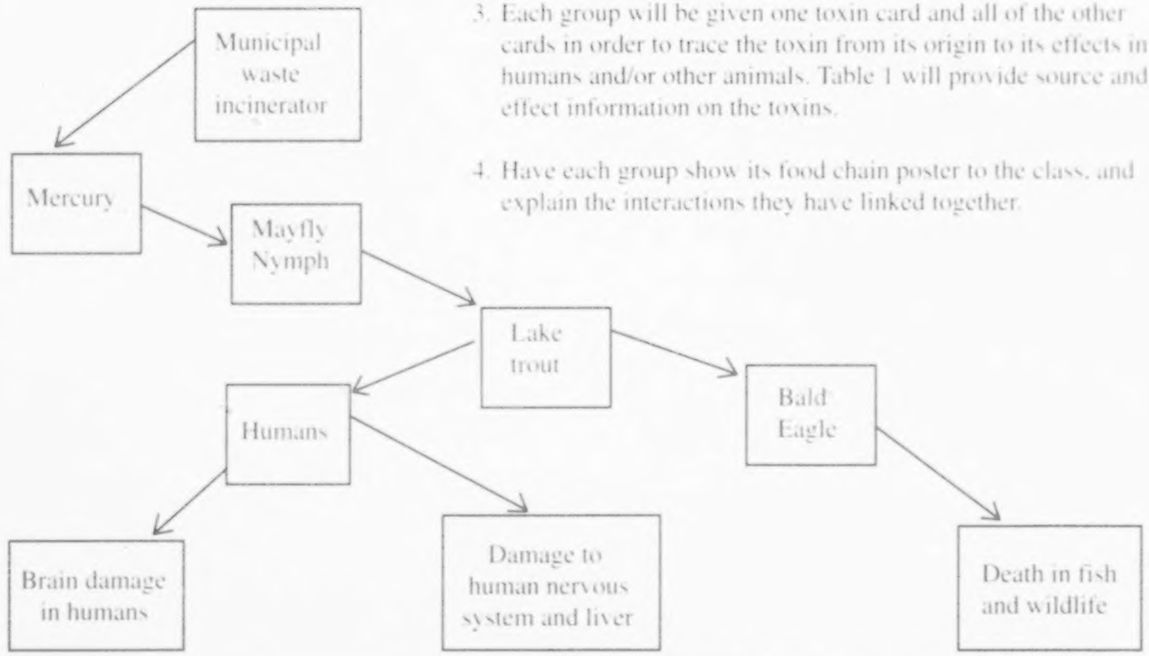

Municipal waste incinerator
Mercury
Mayfly Nymph
Lake trout
Humans
Bald Eagle
Brain damage in humans
Damage to human nervous system and liver
Death in fish and wildlife

Table 1. Toxins Source and Effect Information.

Name of Toxin	Uses	Source of Toxin	Effects of Toxin
Lead	Used in gasoline, paints, glazes, pipes, and roofing materials	Burning leaded fuels, incinerator emissions, boilers	Toxic effects on humans, fish and wildlife; can cause brain damage
Arsenic	Used in pesticides, smelters, glass production	Pesticide use, coal combustion, primary copper smelters	Poisonous to humans, fish and wildlife
Mercury	Used in batteries, paints, industrial instruments, and pulp and paper mills	Natural, coal combustion, municipal waste incineration, copper smelting, sewage incineration	Affects the nervous system and permanent damage can result; the brain may also be damaged
Benzopyrene (BaP)	Not used alone but is found as a by-product of burning fossil fuels	Combustion processes, such as wood burning, cigarette smoke, and coke oven emissions	Believed to be cause of high incidence of tumors in fish; carcinogen
Hexachlorobenzene	Used to control insects	Pesticide use, manufacture of chlorinated solvents	Linked to nerve and liver damage; suspected to cause birth defects
Additional Airborne Toxins No Longer Produced in the USA:			
PCBs	Once used in industrial products-paints, plastics, electrical transformers	Existing landfills, spills, leaking transformers	Illness develops in humans; fatally toxic to fish and wildlife
DDT, dieldrin	To control insects, fungus, rodents, and weeds	Banned in USA, but still used in Mexico, Central and South America	Will accumulate in humans, fish and wildlife; can cause cancer in humans; toxic to fish and wildlife
Toxaphene	Pesticide used on cotton crops	Was used in southern states, including Texas, Georgia, Alabama and Louisiana	Extremely toxic to fish
Dioxin	Not used alone but is found as a by-product of manufacturing herbicides	Improper incineration of herbicides and leaching from land disposal	Human illness, livestock mortality, extremely toxic

Sources: *Hilleman, 1988; EPA, 1987*

REVIEW QUESTIONS

1. With the use of the constructed food chain, explain what bioaccumulation and magnification are and how these factors cause health disorders in humans and animals.
2. List and explain different types of human activities that produce airborne toxins and what effects these toxins have on humans and animals.

EXTENSIONS

1. Look up information on the percentages of toxins found in the Great Lakes that probably reached there on air currents. Use your maps to determine where these toxins may be originating.
2. Do a study on how incinerators work and how they are regulated.
3. Choose a city and discuss the human health effects that might be found in its residents as a result of the airborne pollutants.

Answers to Review Questions

1. Varies by choice of toxin.
2. Refer to Chart 1 in Activity A of this section and Table 1 of Activity C, which is on this page.

Teacher's Note

A public health advisory chart, which indicates the fish that are considered dangerous to eat, is included with the activity "Which fish can we eat?" These restrictions are a reflection of the bioaccumulation of toxins in those fish.

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Toxins	**DDT**	**PCBs**
Toxins	**Dioxins**	**Toxaphene**
Toxins	**Mercury**	**Lead**
Toxins	**Arsenic**	**Benzopyrene**
Toxins	**Hexachlorobenzene**	**Dieldrin**
Effects of Toxins	**Human Cancers**	**Brain Damage in Humans**

Effects of Toxins	**Tumors in Fish**	**Birth Defects in Humans**
Effects of Toxins	**Death in Fish and Wildlife**	**Damage to Human Nervous System & Liver**
Effects of Toxins	**Human Illness**	**Livestock Mortality**
Plants & Phytoplankton	**Cattails**	**Blue-Green Algae**
Plants & Phytoplankton	**Water Lilies**	**Duckweed**
Plants & Phytoplankton	**Rice Cutgrass**	**Purple Loosestrife**

Food Chain: Birds	**Mallard Duck**	**Bald Eagle**
Food Chain: Birds	**Seagull**	**Blue Heron**
Food Chain: Birds	**Red-Tailed Hawk**	**Blue-Winged Teal Duck**
Food Chain: Fish	**Lake Trout**	**Yellow Perch**
Food Chain: Fish	**Coho Salmon**	**Walleye**
Food Chain: Fish	**Catfish**	**Alewives**

Food Chain: Mollusks, Insect Larvae and Zooplankton	**Caddisfly**	**Snails**
Food Chain: Mollusks, Insect Larvae and Zooplankton	**Zebra Mussels**	**Daphnia (Zooplankton)**
Food Chain: Mollusks, Insect Larvae and Zooplankton	**Mayfly Nymph**	**Freshwater Clams**
Food Chain: Mammals	**Mice**	**Beaver**
Food Chain: Mammals	**Red Fox**	**Raccoon**
Food Chain: Mammals	**Rabbit**	**Muskrat**

Food Chain: Mammals	**Human**	
Human Activity & Industries	**Incinerators and Boilers**	**Copper Smelters**
Human Activity & Industries	**Sewage Incineration**	**Manufacture of Chlorinated Solvents**
Human Activity & Industries	**Pulp and Paper Mills**	**Production of Glass**
Human Activity & Industries	**Cigarette Smoking**	**Use of Leaded Fuels**
Human Activity & Industries	**Application of Agricultural Pesticides**	**Coal Combustion**

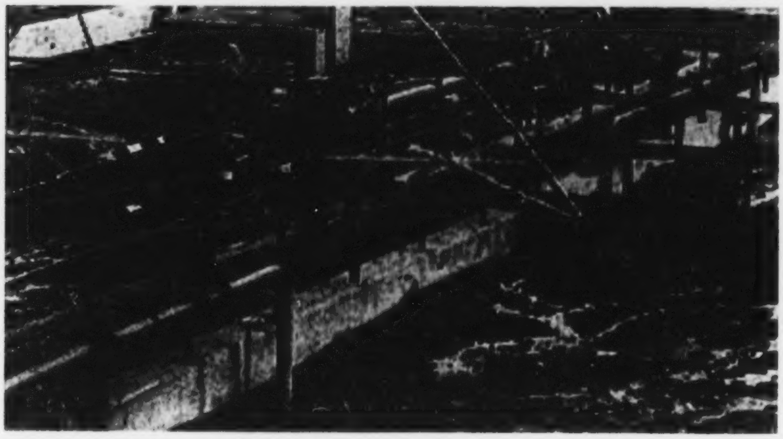
Could we live without chlorine in the Great Lakes?

In the modern Western societies, people have become accustomed to many lifestyle conditions. For example, people expect and demand clean air and water, security, jobs, a clean environment for recreation, etc. However, such demands often create many problems. During the 1960s, when environmental law was not as stringent as at the present time, human demand for products increased industrial pollution, resulting in high use of pesticides, herbicides, and some indiscriminate dumping of toxic wastes. As the next decade approached, a new consciousness began to develop, and a number of significant events occurred in the Great Lakes region that would increase this concern. As dramatic examples, debris in the heavily polluted Cuyahoga River caught fire outside Cleveland, Ohio, and a toxic waste dump was discovered under the community of Love Canal, New York.

These incidents and many others nationwide gave impetus to the environmental movement and the legislation for which it is called. This legislation included the Clean Air Act, the Clean Water Act, the Comprehensive Environmental Response, Compensation and Liability Act (also known as the CERCLA or "Superfund"), as well as many others. However, even though much of this legislation was enacted in the 1970s, it is continually amended as the result of new discoveries concerning chemicals and their impacts.

One such amendment to the Clean Water Act proposes a "chlorine sunset," eventually resulting in virtual elimination of chlorine related environmental issues. Such an amendment would ban all discharges of organochlorines formed as the result of chlorine-based bleaching in the pulp and paper manufacturing process. In addition it would require that the EPA make recommendations within 18 months to Congress for zero discharge of other organochlorine compounds. This would likely have an impact on the quality and safety of surface water as well as all chlorine dependent industries.

In this activity, the International Joint Commission (IJC) has determined that an international committee must be formed to examine the impact of such a decision on the Great Lakes region. Following the formation of the committee, a report has to be produced on the impact of this proposed action on the Great Lakes region.



Pulp and Paper Treatment Plant

Materials

- Summary sheet of parties.
- Descriptions of individual roles.
- Map of Great Lakes Region.
- Conflict resolution fact sheet (included).

Optional: Information sheets from various interest groups and library resources.

Earth Systems Understandings

This activity focuses on ESU 2 (stewardship), 3 (scientific process), 4 (interactions), and 7 (careers and hobbies).

Source

Developed by Dr. Tony P. Murphy.

Teacher's Notes

1. The negotiation process should be described briefly by the teacher. An informational sheet on conflict resolution is provided with this activity. It is very important to explain to the class that a consensus must be reached after all participants have spoken. Do not take a vote on any measure. All must agree that they can live with a decision in order for it to be adopted.

2. As you will note, the summary sheet contains a description of the players. The sheet was produced with the view of having the students "walk in someone else's shoes" and try to get to know the perspective of the player. Canada and the U.S. are countries of diversity, and this diversity is utilized in this activity. If you are, or you think your students may be uncomfortable with this, then omit the personal characteristics of the players. The names may also be altered.

3. Committee members may want to refer to the chlorine fact sheet included with the activity in preparing their presentations for the group.

OBJECTIVES

Following this activity, you will be able to:

1. Visualize a complex issue from many different perspectives.
2. Describe the legislative process, its functionaries (agencies, individuals involved in creating legislation), and the time involved in creating environmental legislation.
3. Appreciate the difficulties in consensus-building in environmental disputes.

PROCEDURE

As a class, read "How Can Public Disputes be Resolved?"

1. The class will be divided into seven groups. Each group will have a summary sheet of the potential committee members.

2. Each group will select committee members. There will be a total of seven committee members who will investigate the impact of the Zero Discharge Act on the Great Lakes region. Diplomacy requires that membership will include representatives of the U.S., Canada, and the First Nation Tribes. Each group will have 10 minutes to make the remaining four selections from the summary sheet.

3. Each group will write the candidates they selected on the chalkboard. If each group's list is the same, proceed to step 4. If the lists are different, discuss these differences and resolve them so that one complete list of seven names remains.

4. One member from each group should volunteer to play the role of a committee member. Each group of students will help one committee member assemble a presentation based on the information from the role-play sheet and additional sources. Charts, data, posters, or other visuals should be used in each player's presentation. The following week, the presentations will be made during the meeting of the committee.

5. At the committee meeting, each of the committee members will put forward a different aspect and supporting data on the issue. Once the presentations are finished, negotiations should begin to determine the action to be recommended to the committee.

6. Finally, a report is to be completed, compiled from the enlarged scripts and reference materials used by the different groups. Each group is responsible for a section of the report

dealing with its representative. A consensus decision must be made on acceptance of the final report by the international committee on behalf of the IJC.

REVIEW QUESTIONS

1. What is the negotiation process used in this meeting? List the characteristics of this process. What difficulties do you see in this process? Do you think it can be used in all situations?

2. Trace the possible pathways of chlorine through all the subsystems of an ecosystem such as the Great Lakes. How does this chemical relate to the hydrosphere, lithosphere, atmosphere, biosphere, and cryosphere? How can industries prevent chlorine from entering systems? How can you personally prevent chlorine from entering the system?

3. List some of the benefits and the problems associated with chlorine dependent industries. Which list is longer? Which is more important?

EXTENSIONS

1. All the technology that we have created has an impact on the planet, some positive, some negative. Industrial polluters often say that environmental contamination should be prevented, but they actually mean that it should only be limited or controlled at the end of a pipe. Elimination of the actual pollution is rarely considered. Also, because people constantly consume and demand more goods, more pollution is probable. Consumers must share some of the blame for this pollution.

   Do you agree with this? How much are people to blame for the current situation of the environment? Could we survive in an environment that is not so clean? Consider these questions. Give some examples of what you could personally do to alter (or adapt to) the current situation. Make a list of five behaviors that you want to change or have changed over the years as a result of increasing environmental knowledge.

2. Other chemicals, such as lead, PCBs, mercury, etc., are also toxic. How do they enter the food chain, and what impact do they have on the Great Lakes ecosystem and human health? Explore these questions through other ES-EAGLS or other information sources.

[The Chlorine Council has produced some excellent videotapes for classroom use. They are designed to show the range of uses of chlorine products and suggest how life would change without them.]

"Building blocks of our world: Chlorine" 6 minutes VHS. Free from The Chlorine Institute, 2001 L. St. NW, Washington, DC 20036, (202) 775-2790.

"Chlorine does a world of good" (Community version, 10.5 minutes VHS) Free from the Chlorine Chemistry Council.

The Canadian Chlorine Coordinating Committee has a new web site at www.cfour.org that is dedicated to providing a science-based view regarding the uses of chlorine and chlorine chemistry.

SUMMARY SHEET OF PARTIES

The International Joint Commission (IJC) is to form a committee to examine the impact of the proposed ban of chlorine in the Great Lakes region (or proposed amendment to the Clean Water Act). The budget for this committee is approximately $40,000, which means that the committee can only have seven people on it. Because the IJC is involved, three of the people on the committee have to be representatives of the U.S., Canada, and First Nations. The committee will have a month to hold its preliminary selection meeting, its negotiation, and the production of its report.

The four other members of the committee may be selected from the following roles.

Ken Congress, a representative of the state of Wisconsin, is a middleaged politician who has served his constituency for a number of years. While he views the aspiration of a clean, healthy environment as being very noble, he wants to know who will pay for this if the ban is successful. Funding is necessary to have a clean environment. He is worried about the impact the ban will have on the industries in his state.

John United, a representative of the state (province) of . . . . [Minnesota, Ohio, New York, Pennsylvania, Illinois, Indiana, Michigan (Quebec, or Ontario)], is a young, newly elected politician, and he is impressed that a consensus approach is being used in this matter. While he understands both sides of this issue, at the moment he is undecided on what way to vote until he hears some more evidence.

Bea Healthy, a representative of the state (province) of . . . . [Minnesota, Ohio, New York, Pennsylvania, Illinois, Indiana, Michigan (Quebec, or Ontario)], is a young politician. For this representative, the issue of health is of primary importance, and she believes that this is the only issue to be contemplated.

B. Leach, a representative of the chlorine industry, is concerned at the probability of the ban on all discharges of chlorine into water. A middle-aged professional, he deals mainly with public relations issues for the chlorine Industry. He reminds people that they use chlorine-derived products on a daily basis, although people generally are unaware of this fact. His main objection to the proposal is that banning chlorine would have a major impact on the society and economy of the U.S. and Canada.

P. Abe Err is a representative of the pulp/paper industry. He is concerned about the proposed ban on the discharge of chlorine and the implications for this industry. He works as a senior executive in a paper industry in the Great Lakes region. He is middle-aged and raises a family with a wife and two children. He believes that people should realize the consequences of this ban on the pulp/paper industry and the economy of the region.

Crystal Claire is scientist and representative of a group of citizens who would like to see the ban on chlorine passed. She has worked with a number of other scientists on the possible effects on human and wildlife health. Her professional career involves working for a non-profit organization that deals with environmental and nonenvironmental issues. She is middle-aged with a young daughter. Her main concern is with human health impacts, although her organization has also investigated wildlife health problems.

Di Oxin is representative for citizens against the ban. As a long term resident of the region, she has sailed and fished in the Great Lakes. A senior citizen, she is concerned with the impact on the local and regional economy, especially as her grandchildren will soon seek employment. She has been involved in previous campaigns on environmental issues and has been a vocal representative, often quoted in the media.

F. Waters is member of the environmental group Greenpeace (or Pollution Probe). A recent college graduate, he has been employed by the group for 2 years. He has training in policy analysis and environmental issues. During his college years, he was involved in various protests concerning environmental polluters and has been working for a number of years on the chlorine ban project.

U.S. REPRESENTATIVE

My name is *Janet Myers*, and I represent the United States governmental interests in this issue. The purpose of this committee meeting is to hear the ideas and concerns of various groups involved in this issue. As you know, the International Joint Commission (IJC) has announced that it wishes to reduce discharges of chlorine into the Great Lakes, and efforts are continuing at the federal level to require industries to eliminate the use of chlorine under the Clean Water Act.

Once this meeting is completed, each of the government representatives will return to his/her own country and discuss the results of this town meeting with other officials. Recommendations for further action on the issue and its impact on the represented nations, the environment, and the economic stability of the area will be made. I would like to thank the groups and organizations for selecting the representatives attending this meeting. Before we begin this meeting, I would like to remind the members that we are here to listen to your concerns; we want to produce a document in which everyone will have contributed so that all can feel happy with the recommendations that will have been proposed. My Canadian colleague will outline the format and the agenda that will be followed, and I trust that this meeting will be fruitful and add some new dimensions to the issue at hand.

Thank you for giving me the opportunity to speak.

CANADIAN REPRESENTATIVE

My name is *Jack Collins*, and I am a representative of the Canadian federal government. I would like to welcome you to this committee meeting. As Ms. Myers, my American counterpart, said, our objective here is to listen to you as representatives of your groups and for us to leave with an idea of the best approach to the task before us. We have an important and difficult task to perform and would like to come to a consensus on the best and most equitable approach to use in achieving the result.

We need to treat the issue in a conscientious manner and weigh the impacts that the proposed ban will have on the various groups represented here and the general public. For this meeting to proceed efficiently and effectively, these rules need to be followed:

1. We all agree to follow the agenda as it is currently organized.
2. All the interests of the various parties need to be heard.
3. No name-calling, heckling, or interrupting will be permitted when another speaker is outlining his or her views/interests.
4. People may use whatever appropriate means and materials necessary for the presentation of their points/interests.
5. Each person has a definite role as a representative of one specific organization and cannot represent any other group.
6. All groups must reach a decision or a consensus on the report. No vote will be taken.

Thank you for giving me the opportunity to speak.

FIRST NATIONS REPRESENTATIVE

My name is *Ron Powers*, and I represent the various First Nations tribes that live and fish in the Great Lakes region. We have fished for many years in this area and were glad to see the 1970s ban on harmful chemicals that caused problems for the fish and eagles. However, we again have become concerned with the reappearance of problems with fish in the region. Tumors are once again beginning to affect the fish, and we are concerned for the health of our people and the environment.

As a nation and people, we hope that this meeting will consider not only the economic impact that a chlorine ban will have, but also the impact that continued use of this chemical will have on the health of the environment and human health. It is important to remember and to weigh into any proposal the health of wildlife and people. We need to be concerned for every person and every plant and animal. Quality of life is about a healthy environment and being able to enjoy it. So, let us consider these issues carefully.

When people hear about the contaminated fish in the Great Lakes, it makes them nervous about eating such fish. Of course, we need to recognize that not all the fish in the lakes are contaminated to the same degree. Fatty fish will accumulate more toxins in their fat tissue; fish near industrial and agricultural points will tend to be more contaminated than fish in deeper water.

> From a tribal perspective, zero discharge of harmful and toxic substances into the waters of the Great Lakes is a goal that must be vigorously pursued. While zero discharge may not be possible in the immediate future, elimination of additional discharge of toxic contaminants into the Great Lakes is imperative. Cooperation from federal, state, and tribal agencies; industry; environmental groups; and the public sector is required to meet the goals of a healthy Great Lakes ecosystem.
>
> Native Americans believe that man is one with his environment, not master of it. In this view, to discharge chemicals into the environment and cause it damage is to cause damage to oneself. Unfortunately, the truth of this philosophy is becoming painfully obvious, as evidenced by the tremendous damage man has already inflicted upon his environment. As stewards of our environment, we must recognize the Great Lakes as a fragile, irreplaceable treasure that represents a system that we are all part of and dependent upon. The Great Lakes have sustained life for many generations of Native Americans, and a commitment must be made to protect and preserve this resource for future generations.

Thank you for giving me the opportunity to speak.

[Quotations from a *Zero Discharge/Virtual Elimination of Persistent Toxic Chemicals: A Tribal Fisheries Perspective*. 1993. Amy L. Owen, Chippewa/Ottawa Treaty Fishery Management Authority, Sault St. Marie, Michigan.]

STATE (PROVINCIAL) REPRESENTATIVE

My name is *Ken Congress*, and I represent the state of Wisconsin. While I am pleased at the meeting and the goals and objectives of gathering all these people together, I must say that I am deeply concerned about the impact of this ban on the employment in my home (state or province). While we all may aspire to a clean and healthy environment, we must also realize what is at stake here. Thousands of jobs in the production of chlorine and its use in the paper and pulp industry may vanish. Add to this the numerous other jobs in service industries, and we could be looking at a total loss of over 1 million jobs, plus tax revenue. How is that to be recouped? How do we pay for schools, roads, infrastructure?

Yes, I would like a healthy, clean environment; but are we willing to pay the cost? Is the possible risk to a small number of individuals worth the economic and social havoc that will be caused by the loss of the pulp/paper industry and other chlorine-dependent industries to all of us? Just examine the costs and employment figures for chlorine-dependent industries in the Great Lakes region and the U.S. and Canada. What will replace these vast amounts of money should we ban chlorine? What will become of all the workers? How will we pay for a clean environment?

Table illustrating the 1990 Value of Chlorine Chemistry (various industries) to the Great Lakes region, the U.S. and Canada. All costs are in U.S. Dollars.

	Processing Plants	PVC Fabrication Plants	Total Number of Plants	Direct Employment	Total Attributable Employment	Direct Wages ($ million)	Total Wages ($ million)
Wisconsin	15	63	78	8,175	24,991	211	598
Minnesota	6	64	70	5,379	12,035	119	281
Illinois	31	130	161	10,887	39,116	314	970
Michigan	25	153	178	18,741	65,889	627	2,064
Ohio	30	219	249	26,076	78,592	631	2,239
New York	36	104	140	11,917	29,267	319	677
Indiana	12	143	155	13,106	38,181	326	1,006
Pennsylvania	31	132	163	13,037	42,783	336	1,001
U.S. Total	718	2,530	3,248	366,738	1,314,971	9,939	31,349
Ontario	29	61	90	9,902	32,614	268	881
Quebec	19	40	59	5,249	15,712	142	424
Canada Total	103	215	318	28,350	84,529	766	2,283
U.S. - Canada Total	821	2,745	3,556	395,088	1,395,088	10,706	33,632

(Source: Charles Rivers Associates, 1993.)

If we tightened pollution laws and regulations, will that have the same impact? I think we need to examine such concerns as an integral part of any alteration in the law. Remember, once an amendment is passed, it will change our lives forever. I caution you all to remember that not only is the natural environment at issue here, but the human environment is at risk of collapse.

Thank you for giving me the opportunity to speak.

State (Provincial) Representative

My name is *John United*, and I represent the state (province) of . . . . [Minnesota, Ohio, New York, Pennsylvania, Illinois, Indiana, Michigan, (Quebec, Ontario)]. This is a very important issue to the people whom I represent. Environmental issues can often become emotional, because they deal with topics that people are extremely concerned about, even fearful for the damage to the environment or to their health or the health of their children. When people become emotional about an issue, it becomes more difficult to resolve, because people fear that their very existence is threatened. However, by involving people from the beginning in this process, it is hoped that everyone will contribute to the knowledge concerning the issue. The resulting decision will be seen as fair and worked toward by all the groups.

As you are all well aware, it is difficult to satisfy all of the people all of the time. However, if people are not involved in decisions that affect their lives deeply, then more severe problems can occur. It is hoped that in this consensus-building process, the various groups' interests will be considered, and the final decision will include elements that satisfy everyone's needs. Even though we think that we know where the final outcome of this process is heading, through consensus building we may be able to attain the goal of the committee in a more equitable manner. My position is unclear at the moment. I am uncertain of the recommendations I will make to my constituents. Before I make any final decisions, I would like to become more informed on the issue and am glad to be here at this meeting to do just that.

Thank you for giving me the opportunity to speak.

STATE (PROVINCIAL) REPRESENTATIVE

My name is *Bea Healthy*, and I represent the state (province) of . . . . [Minnesota, Ohio, New York, Pennsylvania, Illinois, Indiana, Michigan, (Quebec, Ontario)]. I am attending this meeting to voice my concerns and the anxieties of my constituents on this issue of chlorine. I attended a local town meeting in my home state (province) concerning the chlorine ban. My question is: Can we afford not to ban these chemicals? After hearing all the evidence, I am surprised it took so long for this ban to be formulated.

Examining all the evidence I have heard and seen, I would like to say that chlorine chemicals with their potential risks really frighten me. I am not alone in these feelings, according to my constituency. Yes, I realize that many jobs are in danger and lots of funds are in jeopardy, but what price do we put on a life, a single life? Is all the money in the world able to replace the life of a person? How do you tell people that you know these chemicals are dangerous, but for the good of society they are necessary to use? How do you tell this to someone who has breast cancer, or the parent of a handicapped or deformed child? I don't want to tell people this, do you?

I think that the evidence is conclusive enough at this stage to ban organochlorine chemicals altogether. It is time to sunset, retire, or ban these chemicals. Let's examine what happened to the amount of chemicals in the environment and human body fat content when they were sunsetted.

Many people at this meeting and in the chlorine industry will say that a total ban of chlorine is counterproductive to society. How can they say that with the current evidence? We cannot allow current impacts of this group of chemicals on human health and wildlife to continue. Neither can we wait to test all of these chemicals individually; we just do not have the time. This is an urgent problem. We must act and act now. But what frightens me even more is that even if we ban chlorine now, residues of dangerous chemicals that still persist in sediments will be transferred in the food chains. Once the ban is in place, the next logical step, in my mind, is to try to remove such dangerous chemicals from the existing polluted and contaminated areas.

Table illustrating percentage change in human body fat and sediments after sunsetting chemicals in certain practices.

Pollutant	Time Period	Percent Change	Control Measure
Lead emissions	1975 - 1985	-86%	removed from gasoline
DDT (in body fat)	1970 - 1983	-79%	agricultural use banned
PCBs (in body fat)	1970 - 1980	-75%	production banned
Mercury (in sediments)	1970 - 1979	-80%	replaced with chlorine production

(Source: Mausberg and Muldoon, 1991.)

Finally, I would like to take this opportunity to say that I am pleased to be invited to this meeting. I am glad to see that various groups are involved in this; and hopefully we will reach a consensus on the approach to be taken in this issue. I do hope that we can come to an arrangement on this most serious matter before us.

Thank you for giving me the opportunity to speak.

CHLORINE INDUSTRY REPRESENTATIVE

My name is *B. Leach*, and I represent the chlorine industry. As you know, we are all here to discuss the movement at hand to ban all discharges of chlorine into water. However, we use chlorine-derived products on a daily basis, although people generally are unaware of this fact. Chlorine products include: polyvinyl chloride (PVC), other plastics, flame retardants, chlorinated solvents, hydrogen chloride (used in a variety of food processing and industrial applications), laundry bleaches and detergents, dry-cleaning fluids, and water purification and crop protection chemicals (pesticides, herbicides and fungicides). Chlorine's use in the manufacture of certain products includes pigments in paints, paper, plastics, nonstick cookware, and pharmaceuticals.

The proposed ban has resulted from the belief that "certain chlorine-containing compounds have been found to pose unacceptable health and environmental risks. These risks should not be ignored. Any situation where chlorine-dependent processes or chlorine or chlorine-containing compounds creates unacceptable health and environmental risks should be corrected. In April 1992, the International Joint Commission's Water Quality Advisory Board recommended that the United States and Canada consider phasing out the use of chlorine and chlorine-containing compounds as industrial feedstocks. However, any public policy debate that proposes the banning of all chlorine production and use should take into account not only any risks associated with chlorine's use but also the social and economic impacts of such a ban on the United States and Canada and the risks associated with the use of substitute products."

The economic benefits of the chlorine industry were outlined in a recent report conducted by the Charles River Associates (CRA). The figures represent the "benefits (or savings) that chlorine currently provides to the consumer and the contributions that chlorine-dependent industries provide to local, regional, and national economies."

What we are dealing with here, ladies and gentlemen, is a multi-billion-dollar industry. Any ban or the use of substitutes will cost consumers and the industry millions of dollars in additional costs and could result in the closure of many industrial plants. The CRA report notes that the "use of substitutes for chlorine-based products and processes would cost an additional $91 billion per year in the U.S. and $11 billion per year in Canada" (p. 2). The investment required to construct facilities to produce substitutes would approach $67 billion. This construction would probably take 10 to 20 years, and it is likely that consumers would be forced to bear the burden of this cost through higher consumer prices.

Let's examine the figures in this table [next page].

Besides this cost, let's examine the number of people employed directly and indirectly in this industry. "In 1990, chlorine-dependent industries employed almost 400,000 workers. An additional 1.0 million workers are employed in related industries and services . . . Nearly 1.4 million jobs in 48 U.S. states and nine Canadian provinces depend on chlorine production. Total wages exceeded $33 billion. If chlorine production were shut down, many of the workers would lose their jobs, and society would bear the cost."

Therefore, as you can see, banning chlorine will have a major impact on the social and economic fabric of the U.S. and Canada. I would ask this committee to seriously consider the consequences of this chlorine ban.

Thank you for giving me the opportunity to speak.

Ohio Sea Grant Education Program

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Table illustrating the 1990 Value of Chlorine Chemistry. All costs are in U.S. dollars.

		Economic Value		
To Consumers	**Units**	**United States**	**Canada**	**Total**
Economic benefits				
In direct uses	$Billion/Year	9.8	1.2	11.0
In products containing chlorine	$Billion/Year	31.4	3.3	34.7
As a facilitator	$Billion/Year	49.9	6.8	56.7
Total	$Billion/Year	91.1	11.3	102.4
To Local Economies				
Economic contributors				
Value of sales	$Billion/Year	71.4	8.5	79.9
Employment, direct Workers		366,700	28,400	395,100
Employment, indirect	Workers	948,300	55,600	1,003,900
Employment, total Workers		1,315,000	84,000	1,399,000
Wages, direct	$Billion/Year	9.9	0.8	10.7
Wages, indirect	$Billion/Year	21.4	1.5	22.9
Wages, total	$Billion/Year	31.3	2.3	33.6
Gross domestic investment	$Billion	56.8	4.4	61.2
Balance of trade	$Billion/Year	+2.9	+0.1	+3.0

(Source: Charles Rivers Associates, 1993.)

What is bleach?

According to the Clorox Company, bleach is not the same as chlorine. While chlorine is used in its production, liquid bleach has the active ingredient sodium hypochlorite. The solution decomposes into salt and water.

The Clorox Company has made several attempts to address environmental issues in the manufacturing of its products. One example is the construction of a manufacturing plant surrounded by a 75-acre wetland that supports various wildlife species. The company has also strived to reduce accidental toxic releases, lower reported releases of chlorine (592 pounds in 1989 compared to 107 pounds in 1993), and increase the use of recycled materials in packaging products. (Source: The Clorox Company, *Environmental Progress Report 1995*.)

For more information contact:
The Clorox Company, 1221
Broadway, Oakland, CA 94612.
Phone: (510) 271-7732 Fax:
(510) 271-2946

All the information used in this sheet is taken from a Final Report, Assessment of the Economic Benefits of Chlor-Alkali Chemicals to the United States and Canada, prepared for The Chlorine Institute, Inc., 2001 L Street NW, Washington, D.C. 20036, published in April 1993.

PULP/PAPER INDUSTRY REPRESENTATIVE

My name is *P. Abe Err,* and I represent the pulp/paper industry. As you realize, this ban on the discharge of chlorine could have serious implications for our industry. We are taking steps to help the present situation but are concerned about the impact that a total ban will have on the industry. One of the main uses of chlorine is in the pulp and paper industry. It is used directly to bleach wood pulps in the production of high-quality papers. While all pulps are not bleached, in 1990 almost 45 millions tons of bleached pulps were produced by 156 mills in the U.S. and Canada.

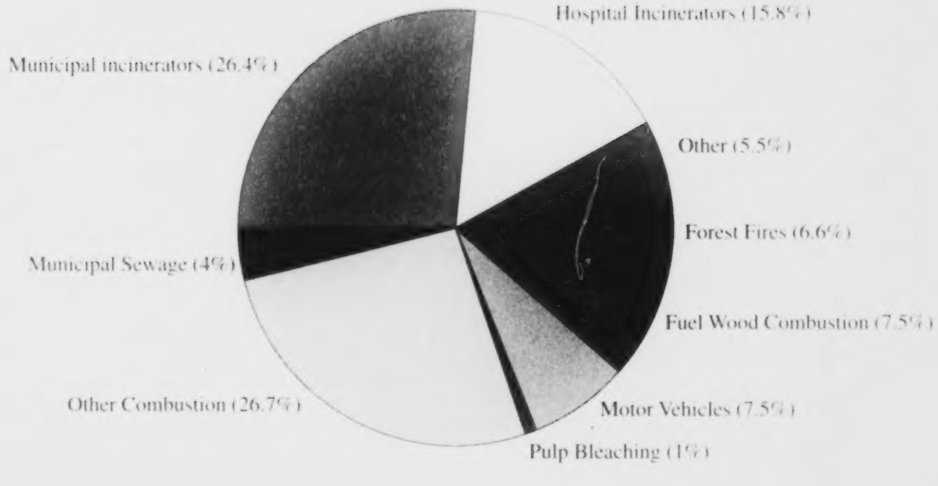
In the process of producing pulp, various treatment sequences can be used, depending on the wood used and the final product desired. Once the sequence (which entails extensive recycling and recovery of intermediate wash and byproducts, etc.) has been established within the overall design of the mill, then any alterations, no matter how small, are extremely difficult and expensive. Considerable investments have been made by the industries involved. Just examine the figures in this chart.

	Investment (U.S. $Millions)
Wisconsin	1,583
Minnesota	339
Illinois	1,855
Michigan	4,742
Ohio	2,372
New York	2,216
Indiana	1,388
Pennsylvania	1,737
U.S. Total	56,837
Ontario	1,734
Quebec	818
Canada Total	4,437

Table illustrating the investments made by companies dependent on chlorine in the Great Lakes region, the U.S., and Canada. All costs are in U.S. dollars. (Source: Charles River Associates, 1993.)

In addition, we in the pulp and paper industry believe that this industry is being used as a scapegoat by many of the politicians and environmental groups. Looking at the estimated releases of dioxin in the United States in 1991, it is clearly visible that incinerators pose a far greater health problem than pulp bleaching.

For some time, the pulp and paper industry has sought the development of cost-effective technologies that would decrease the discharges of chlorinated compounds in effluent. Generally, these technologies substitute chlorine dioxide for a portion of the chlorine formerly used in the bleaching cycles. Increased efficiency in the process has already reduced the discharge of toxic substances such as TCDD. During 1988-89, 104 U.S. mills surveyed generated a total of 2.5 pounds of TCDD; in 1993 this was reduced to below 8 ounces per year. The amount of chlorine used in the bleaching process is projected to fall from 1.4 million tons in 1990 to 920,000 tons in 1995. Increased use of hydrogen peroxide and oxygen will also aid in the decline of chlorine.



Estimated Releases of Dioxin in the United States (1991). (Source: International Joint Commission, Volume 2, 1993.)

However, while some companies have altered their system entirely to the production of paper without chlorine, the range of products we have come to expect may not be possible without some use of this bleaching agent. This alteration has been expensive:

> "The United States industry estimates that it has already spent over $1 billion implementing these changes in the short time since dioxin was attributed to the pulping process.
>
> Ontario's 26 pulp and paper factories employ 16,000 people, providing one third of all the manufacturing jobs in northern Ontario. In Quebec, employment in this industry is also substantial. Between the U.S. and Canada, employment in this industry and the millions of dollars produced will be in jeopardy if this ban proceeds.
>
> The pulp and paper industry has demonstrated that it is achieving virtual elimination — voluntarily, at great expense, and without having to eliminate all use of chlorine compounds. Thus, there is no rational basis for singling out the pulp and paper industry, or for banning the use of all forms of chlorine in the pulping process, when virtual elimination is being achieved through other process modifications."

Thank you for giving me the opportunity to speak.

[All quotations are taken from the 1993 Report of the Virtual Elimination Task Force to the International Joint Commission. *A Strategy for Virtual Elimination of Persistent Toxic Substances*. Volumes 1 & 2.]

SCIENTIST

My name is *Crystal Claire*, and I represent a group of citizens who would like to see this ban on chlorine passed. As many of you know, what we are dealing with here is a health issue. What good are jobs to people if they are not healthy enough to work in them? What good is an environment if it is unhealthy and cannot be enjoyed? But many industry representatives will say that we are being overly emotional. They ask, "Where is your proof?" Well, here is our proof.

When it was discovered that some chlorinated insecticides, such as the pesticide DDT, were toxic and persistent, they were banned or regulated in the 1970s by the U.S. EPA. A chemical that is persistent accumulates in the body fat of animals and is passed along the food chain, up to the final consumer. In the case of DDT, the final consumers were often raptors – birds of prey, such as eagles, hawks, falcons, owls, etc. This chemical caused numerous problems for the birds, including:

- Thin egg shells that broke prematurely, killing the young
- Birth defects, such as crooked beaks
- Reproductive defects, such as infertility.

However, people are also the final consumers for some of the food affected by DDT. Just examine this chart and the defects caused by exposure to organochlorines.

Chart illustrating the variety of health effects observed in wildlife in the Great Lakes Basin. Blank cells do not necessarily mean that there is no effect on wildlife, only that research has not been performed on the species.

Species	Reproductive effects	Eggshell thinning	Generational effects	Deformities	Organ damage	Behavioral changes	Hormonal changes	Metabolic changes, "wasting"	Immune suppression	Tumors
Bald eagle	●	●	●	●		●		●		
Beluga whale	●			●	●		●		●	●
Black-crowned night heron	●	●		●						
Caspian tern	●		●	●		●		●		
Chinook-coho salmon	●				●		●			●
Common tern	●				●	●		●	●	
Double-crested cormorant	●	●	●	●	●	●	●	●	●	
Forster's tern	●		●	●	●	●		●		
Herring gull	●	●	●	●	●	●	●	●	●	
Lake trout	●		●		●	●		●		
Mink	●		●		●			●		
Osprey	●	●								
Otter										
Ring-billed gull	●			●				●	●	
Snapping turtle	●	●	●	●	●			●		

(Source: Hileman, 1993, *Chemical and Engineering News.*)

In addition, the targeted insects for this pesticide developed immunity to the chemical, thus making it ineffective. However, DDT was banned, not because of the adverse effects on wildlife, but because of the possible carcinogenicity (ability to cause cancer) in humans. Other chlorinated insecticides regulated or banned include aldrin, chlordane, dieldrin, kepone, lindane, mirex, and toxaphene. Some of these are still used, but under strict regulations. For example, dieldrin is used as a moth repellent in carpets and rugs, and lindane is an ingredient in a preparation used to kill head lice in children. Fears have recently grown over the use of lindane to kill head lice, as researchers fear it may increase the risk of brain cancers.

Researchers suggest that new disturbing health trends are linked to exposure to organochlorines in the environment. Increases in most cancers, particularly brain, kidney and breast, have created a new interest in this possible link. In Sweden, people born in the 1950s have a greater chance (two to three times) of developing cancer than people born between 1873 and 1882. In the U.S., between 1973 and 1987, cancer deaths decreased in young people, but the overall trend of incidence showed an increase in all age groups.

These health trends are disturbing and need serious consideration. The increase of pollution in our daily lives has an important influence on our health and the health of our children. By considering alternatives to chlorine and its byproducts, we are coming closer to creating a safer and healthier environment for us, our children, and future generations.

Thank you for giving me the opportunity to speak.

CITIZENS GROUP - AGAINST BAN

My name is *Di Oxin*, and I represent a group of citizens who would like this proposed ban dropped. Before I go any farther, I would like to say that I am an environmentalist. I have lived all my life in the Great Lakes region, have fished and sailed the lakes and want to see them maintained as a good resource for everyone's use. However, in these tough economic times, people do not realize the devastating impact that this ban will have on the economy of our region. Around the Great Lakes, 122,000 jobs and $3 billion in wages created by chlorine-dependent industries would be at risk. Studies have shown that 40% of U.S. and Canadian jobs and income are in some way dependent on chlorine and the products of the chlorine industry. Even scientists who realize the potential danger of these chlorine compounds think that a full chlorine ban is an extreme position and ridiculous. "Endocrinologist H. Leon Bradlow of Cornell University's Strang Cancer Prevention Center in New York City acknowledges that all toxic chemicals should be used judiciously and only when suitable nontoxic substitutes aren't available." However, and I quote Dr. Bradlow here, "I think methylene chloride [an animal carcinogen] is a dandy solvent and would hate not to be able to use it" (Quotes from Raloff, 1994. *Science News*.) If a scientist and cancer researcher of Dr. Bradlow's caliber thinks it is safe, then I think it is safe enough for me and you. Just look at all the uses we make of chlorine and the amount of resources it produces.

I would agree that it is imperative to maintain a clean environment, but there is a cost to pay for this. Are we all willing to pay this price, because we all will. Can people live on clean air? We need food and jobs. In my area alone, over 6,000 people would be affected directly by this ban. Taking into account all the service industries that are connected to these primary jobs, over 10,000 jobs may be lost. Factoring in the loss in revenue to local, state, and federal government, well, the figures goes into millions of dollars. And where do the funds to replace this come from? State or federal government? We all know how strapped for money these governments are already. There is no way that they can replace the lost money. Let's face it, a total ban would be disastrous for people and the environment. Where do you think existing money for environmental protection comes from?

A more sensible strategy is to phase out the use of chlorine, to use substitutes, and to reduce the discharge to a level that is not as harmful as current levels. Such a proposal would benefit all the parties involved and reduce health risks, while maintaining the economic structure of the industry.

Thank you for giving me the opportunity to speak.

Estimated benefits of chlorine chemistry to consumers in the United States and Canada.

	Estimated Net Benefits ($Million/Year)	
Use or Application	**U. S.**	**Canada**
Direct uses		
Pulp bleaching	2,100	260
Water treatment	5,430	570
Sodium hydroxide	2,110	400
Potassium hydroxide	120	10
In products		
PVC products	6,125	765
Chlorinated solvents	1,210	140
Hydrogen chloride	400	60
Bleaches, etc.	740	60
Flame retardants	160	20
Polychloroprene	360	20
Crop protection	22,140	2,160
Chlorinated polyolefins	110	10
Polyvinylidine chloride	160	20
As a facilitator		
Propylene oxide	170	20
Epichlorohydrin	435	45
Isocyanates	345	35
Titanium dioxide	470	10
Fluoropolymers	220	20
Polycarbonates	225	25
Pharmaceuticals	47,010	6,590
Refrigerants	500	50
Silicones	480	50
Total	91,020	11,340

(Source: Charles River Associates, 1993.)

GREENPEACE/POLLUTION PROBE

My name is *F. Waters*, and I represent the environmental group Greenpeace (or Pollution Probe). We would like to see the production of PVC, polyvinyl chloride, phased out, as the process creates many harmful substances. In Germany and Austria, city and town planners have created new construction policies that favor non-use of plastics in their new buildings. The reason? Combustion of this plastic at low temperatures is similar to burning in inefficient waste incinerators, which produces toxic substances, such as dioxins and furans. The problem of melting plastic falling on people in fire situations in public buildings is also a safety consideration.

Few useful products can be manufactured from pure PVC. Additives are mixed with it; the added substances are dependent on the final use of the product. Therefore, only a fraction of the total amount of PVC produced can be easily recycled. Any products that are recycled, usually are down-cycled — that is, manufactured into a product that is less valuable than the original commodity (i.e., rug backing). Currently, only 1% of all PVC is easily recycled. Imagine all that plastic used daily that will never be reused. While the Vinyl Institute in Akron, Ohio, is aiming at a recycling rate of 25%, even this is extremely low.

Issues other than PVC production should also be considered. In addition to the problems caused for wildlife by these organochlorines, they also pose a major threat to people in the form of an increased risk of cancer. Chlorinated insecticides already regulated or banned include aldrin, chlordane, dieldrin, kepone, lindane, mirex, and toxaphene. However, some of these are still used, but under strict regulations.

Even when chlorine insecticides are banned, these dangerous chemicals can still enter into our lives by atmospheric transport, on imported foods, and across borders through watersheds. For example, the waste effluent from pulp and paper facilities in the U.S. and Canada may affect citizens of both countries who share common water resources such as the Great Lakes.

The chlorine industry states that banning chlorine will be expensive, that it would "devastate the economies of the U.S. and Canada, with costs of a total phase-out estimated at $102 billion annually. However, a more careful view of the information presented in the report actually supports the feasibility of eliminating chlorine." Let's examine the data.

Table comparing costs of the feasibility of eliminating chlorine.

Project	Estimated costs
Cost to phase-out 100% of chlorine use, U.S. & Canada	$102 billion/yr.
Cost to phase-out 95% of chlorine use, U.S & Canada	$20 billion/yr.
Health care costs for effects of persistent toxic substances, U.S. & Canada $	$75-100 billion/yr
U.S. industry expenditures on end-of-pipe pollution control	$90 billion/yr.
U.S. military budget	$300 billion/yr.
U.S. Savings and Loan Bailout	$500 billion/yr.
Clean-up of toxic and radioactive waste dumps in U.S.	$500 billion - $1 trillion (total)
Direct and tax subsidies for fossil fuels and nuclear power, U.S. government	$53 billion/yr.

(Source: Greenpeace, 1993.)

As stated earlier, the reason that many of these chemicals were banned was based more on the possibility of carcinogenicity for people rather than their impact on wildlife. The main concern with the use of chlorinated chemicals has been the increase in human cancers over the last three decades. Researchers suggest that the new disturbing health trends are linked to exposure to organochlorines in the environment. Increases in most cancers, particularly brain, kidney and breast, have created a new interest in this possible link. In Sweden, people born in the 1950s have a greater risk (two to three times) of developing cancer compared to people born between 1873 and 1882. In the U.S. between 1973 and 1987, cancer deaths decreased in young people, but the overall trend of incidence showed an increase in all age groups.

It is crucial to the safety and health of the environment and people as inhabitants of that environment to prevent the further discharge of chlorine and its byproducts into our surroundings. It is important for us and for our children that we accept this challenge and do the right thing.

Thank you for giving me the opportunity to speak.

[Quotation and chart from "Industry Study Backfires: Chlorine Phase-out is Feasible and Affordable" in the Greenpeace publication, *Chlorine Free*, 1993.]

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Chlorine Homepage. Copyright © 1996, the Chorine Chemical Council. http://c3.org/home.html

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Greenpeace – http://www.greenpeace.org/ A search tool is available for finding chlorine sites and related topics, for example: Greenpeace Human Health and the Environment Reports – http://www.greenpeace.org/~usa/pubinfo/health.html

Human Health Effects of Pollution – http://www.great-lakes.net/pollution/health.html – lists resources, agencies, and reports as sources of information.

Web addresses sometimes change. Do a word search if necessary.

HOW CAN PUBLIC DISPUTES BE RESOLVED?

An Informational Sheet

Disputes arise every day—in the home, in class, at work, between friends, between organizations, etc. Public disputes usually occur when some issue is viewed differently by the various people who could be affected by the outcome of the issue. The resolution of these disputes will depend on the context, the issue at hand, and the people (sometimes called parties or players) involved. At present, disputes are usually resolved through negotiations, the success of which will depend on many different factors.

What makes Public Disputes difficult to resolve?

Many people find conflict unpleasant and therefore avoid it. If they become emotional when the conflict arises initially, people may leap into a confrontation with the other party(ies). Because people are sometimes uncomfortable in conflict situations, a quick resolution is agreed upon, often without fully considering all the issues. Such resolutions are likely to be flawed and could lead to further frustration and further conflict.

When many different parties become involved in a dispute a complicated network of interests evolves. Often, even when it is believed that all the parties are involved in the discussions and have input, a new party (or parties) may emerge and disrupt the situation. With more parties involved, or with certain special types of issues, a wide range of considerations may have to be taken into account. As such, many public disputes "often involve complicated financial questions, complex regulatory procedures, and detailed technical data. The understanding of technical information may vary dramatically among individuals involved in a negotiation" (Carpenter and Kennedy, 1988, 5-6).

As in most confrontations, power will play an important role. "Power comes in a variety of forms, including that derived from financial resources, legal authority, knowledge and skills, numbers of people, access to decision makers, personal respect, and friendships" (page 6 of Carpenter and Kennedy).

In many disputes, the parties do not know each other personally, although they may have dealt with the opposing organization previously. Once the dispute is settled, they may not maintain contact and therefore it may be difficult to establish a cooperative relationship initially. Also, the different organizations involved are likely to have a variety of internal decision-making procedures, which may hamper the negotiation process. This may be especially true of the influence of government rules and regulations.

How are Environmental Disputes different from Public Disputes?

One of the most important considerations when dealing with environmental disputes is that many of them are based on strongly held values. This makes them more difficult to resolve as people rarely, if ever, negotiate their values. For example, to some people the value of clean drinking water cannot be compromised in any situation. (Sometimes, environmental disputes may be based on interests,and these are usually more easily resolved. For example, if a factory building is to be constructed on a forested lot near a residential area, then the factory owner may agree to replant the trees lost in the construction, plus plant additional trees to conceal the building from view. In this way, everyone's interests are met.)

How are Environmental Disputes resolved?

At present, to aid in the solution of environmental disputes, different approaches are considered as conflict management and resolution techniques. These include negotiation, mediation, arbitration, the legal system, or the *Environmental Dispute Resolution* (EDR) Process.

Negotiation

This process should involve some or all of the following points. The decision maker becomes a facilitator of the process, ensuring that as many parties as possible will be involved given the constraints that are acting on the process. It is also important to involve the community from the outset; otherwise, the community may not trust the people involved or what they are doing.

At the beginning of the process, the parties should be involved in shaping the process, creating the ground rules, if possible, agreeing with them, and sticking to them during the discussions. The focus of the problem should be the best possible solution of the problem, not who is correct. To perform this task in the best way, it is crucial that the parties meet face to face to discuss all the issues and interests raised by this dispute. Only in this way is a successful resolution to the dispute possible (although this does not always guarantee a successful resolution).

Any final resolution should be a consensus decision. "The goal of consensus decision making is to reach a decision that all parties can accept" (Carpenter and Kennedy, 1988)

Mediation

This is a process whereby a person is introduced to the conflict and becomes a neutral spokesperson to aid in the resolution of a dispute. The mediator is agreed upon by all the other parties and has no direct stake in the outcome of the conflict. The mediator does not impose decisions, but helps the different parties reach an agreement that each can live with. Mediators are usually people that are well-known to the parties, trustworthy, and have good skills when dealing with people.

Arbitration

This is generally used when disputes are in deadlock without any sign of resolution. Usually in disputes, arbitration is the last resort, because the courts get involved. The arbitrator may be imposed by the court or a local, state, or federal agency. In arbitration situations, the decision made by the arbitrator is final and binding on all the parties. If at any stage parties do not abide by the resolution, they may have to return to court.

Legal System

Similar to arbitration, parties may seek the aid of the legal system if the dispute is deadlocked or if they believe that they have been wronged in a decision. Sometimes, the judge may appoint an arbitrator or decide the best remedy to the dispute. As in arbitration, such judge-made decisions are binding on all the parties involved.

Environmental Dispute Settlement Process

One of the techniques used in many environmental disputes is the Environmental Dispute Settlement Process. As defined by Crowfoot and Wondolleck in 1990, this is based on three key elements:

(1) "Voluntary participation by the parties involved;

(2) Direct or "face-to-face" group interaction among the representatives of these parties; and

(3) Mutual agreement or consensus decisions by the parties on the process to be used and any settlement that may emerge" (page 19 of Crowfoot and Wondolleck).

This is a consensus-building approach. People involved in dispute resolution believe that such an approach is best. Each party has input into the process, thereby creating a sense of participation and facilitating a resolution in which everyone wins.

Should the use of chlorine in the Great Lakes region be banned?—A Case Study in Negotiations (or Environmental Dispute Resolution)

The parties and issues that may become involved in an environmental dispute can be explored by examining the proposed chlorine ban in the Great Lakes region. In this situation, the parties that may be affected directly include the citizens in the local area – both the workers in chlorine-dependent industries and the people who want to stop the pumping of chlorine into water, the industrialists who depend on chlorine for production, and the local politicians. However, many other groups may enter the dispute, including environmentalists, scientists, federal and state representatives, and other national representatives when another country is involved. Issues raised by such parties may involve health and economic considerations as well as technical questions on safety to the environment, workers, and the general public.

In the proposed chlorine ban negotiations in the activity "Could we live without chlorine in the Great Lakes?," the IJC is the decision maker and, because of a restricted budget, a committee of only seven people is possible. Also within this committee, three representatives were already chosen because of the international dimensions of a ban.

Already at this stage, it is possible to see that various constraints are working on the negotiation process. In addition, because every party cannot be represented on the committee, implementation of the settlement may run into difficulties.

Examine other local, regional, and national environmental disputes and try to pinpoint the parties and issues involved. Is consensus building always appropriate?

This is a brief description of the resolution techniques used in managing environmental disputes. Additional information may be found in:

Carpenter, Susan L., and Kennedy, W. J. D. 1988. *Managing Public Disputes*. San Francisco, CA: Jossey-Bass Publishers.

Crowfoot, James E., and Julia M. Wondolleck. 1990. *Environmental Disputes: Community Involvement in Conflict Resolution*. Washington D.C.: Island Press.

Produced by the Ohio Sea Grant Education Program at The Ohio State University, 1994. Editor: Tony P. Murphy.

What Are the Concerns About Chlorine?

The current anxiety over chlorine and its products has been growing over a number of decades. This is not just peculiar to North America, but in many other industrial and developing nations as well. To examine the present situation, it is necessary to investigate the historical basis of the issue.

Health of Wildlife and the Environment

Following the publication of various environmental writings in the 1960s, a new awareness began to form concerning the environment and the impact of people, like you and me, on it. After the first Earth Day in 1970 and the establishment of the U.S. Environmental Protection Agency (EPA) in 1972, people began to take their fears and worries to the elected officials in their area and the agencies that were to provide protection for the environment. Subsequent to the discovery that some chlorinated insecticides, such as the pesticide DDT, were persistent, they were banned or regulated in the 1970s by the EPA. A chemical that is persistent accumulates in the body fat of animals and is passed along the food chain, up to the final consumer. In the case of DDT, the final consumers were often raptors – birds of prey, such as eagles, hawks, falcons, owls, etc. This chemical caused numerous problems for the birds, including: thin egg shells that broke prematurely, killing the young; birth defects, such as crooked beaks; and reproductive defects, such as infertility. In addition, some organochlorine pesticides became ineffective from constant use because the targeted insects developed immunity to the chemical.

The manufacture and use of DDT was banned by Canadian federal law in the early '70s (circa 1970). Unlike U.S. practice, this pesticide is no longer manufactured in Canada and exported to other countries for use. DDT levels peaked in 1972, the year the chlorinated insecticide was banned, and remained low until recently. In the Great Lakes in the '90s, fish are again beginning to show high levels of this chemical in their tissues. Long-range atmospheric transport is believed to be carrying the chemical to the region from places where it is still used.

Other chlorinated chemicals causing problems are PCBs (poly chlorinated biphenyls). Even though this group was banned in 1976, PCBs are still in our environment, present in closed transformers, in paints on older ship hulls, storage in warehouses and many landfills, and in contaminated sediments. Even today only certain amounts of some Great Lakes fish can be consumed because their tissue contains PCBs. Such restrictions are also placed on fish from the Boundary Waters, Minnesota, a pristine area far from standard sources of PCBs. Some researchers estimate that more than 70% of PCBs produced worldwide are still in use or stored and could escape into the environment. If this occurred, it could make the present situation appear minuscule.

Declining animal populations resulting from these chlorinated chemicals may be difficult to ascertain, as such deaths may be masked by other causes. For example, since 1987, global populations of marine mammals (dolphin, seal, and whale) have experienced wide-scale die-offs. The immediate cause of death seems to be common viruses and bacteria. However, in some areas researchers found higher levels of PCBs in the tissue of the dead animals than in animals in the general population. This led them to believe that organochlorines in the animals' tissues suppressed their immune systems, making the animals more susceptible to ordinary infections.

Health of Humans

When DDT was prohibited, it was banned not because of the adverse effects on wildlife, but because of the possible carcinogenicity (ability to cause cancer) in humans. Other chlorinated insecticides currently regulated or banned include aldrin, chlordane, dieldrin, kepone, lindane, mirex, and toxaphene. Some of these are still used at present, but under strict regulations. For example, dieldrin is used as a moth repellent in carpets and rugs, and lindane is an ingredient in a preparation used to kill head lice in children. Fears have recently grown over such a use of lindane, as researchers fear it may increase the risk of brain cancers.

The banning of such chemicals in the U.S. and Canada does not safeguard people from their effects either. In 1991, according to the Foundation for Advancement in Science and Education in Los Angeles, 4.1 million pounds of canceled, voluntarily suspended or banned pesticides (including 96 tons of DDT) were exported. Almost half were shipped to developing nations. Many of the chemicals are still used in those nations on food crops. Some will return to the U.S. and Canada on imported crops, by atmospheric transport, or by migratory fish and birds.

As stated earlier, the reason that many of these chemicals were banned was based more on the possibility of carcinogenicity for people rather than their impact on wildlife. The main concern with the use of chlorinated chemicals has been the increase in human cancers over the last three decades. Researchers suggest that some disturbing health trends are linked to exposure to organochlorines in the environment. Increases in most cancers, particularly brain, kidney, and breast, have created a new interest in this possible link. During the '60s, one American woman out of every 20 had the chance of developing breast cancer by the time she was 85. At present, the risk has increased to one in nine. Since 1940, sperm counts in men have fallen by 42%. At the same time, birth defects in male reproductive organs have increased. Scientific research has shown that organochlorines may cross the placental barrier, resulting in damage to the fetus. In Sweden, people born in the 1950s are two to three times more likely to develop cancer than people born between 1873 and 1882. Between 1973 and 1987 in the U.S. cancer deaths decreased in young people, but the overall trend of incidence showed an increase in all age groups.

Dioxin is a word that causes fear in many people, mainly because of the possible connection with cancer. Recent studies in the Netherlands have shown that dioxins and furans, a related chemical group, may retard central nervous system and psychomotor (skills) development in babies.

Dioxin concentrates in fat-rich food, including human breast milk. Scientists believe that up to 12% of an individual's intake of dioxin occurs during the first year of life. However, most scientists and the EPA believe that the benefits of breast-feeding infants outweigh any possible hazards.

American researchers have found a link between TCDD, an extremely toxic dioxin, and endometriosis. This painful disease causes reproductive problems for women and may affect up to 10 percent of the female population.

However, not all scientists agree with the results of reports that show the possible links between human cancers and chlorine containing products. Most do agree that in high doses such chemicals are clearly toxic and carcinogenic, however whether humans are affected by small or minute doses is not as clear. Some would suggest that the chemicals are being used as a scapegoat for many problems that really are not connected to pollution. For example, rising or falling birthrates may be connected to economics and not pollution; the increasing incidence of infertile couples could be a result of their waiting too long before trying to begin a family; and higher rates of certain cancers, such as testicular cancer, may be the product of improved detection and reporting, not an increase in the rate as a result of pollution.

In 1993 the U.S. EPA re-registered 19 of the 270 old pesticides. Reregisteration is a long, laborious process where the chemicals are tested for possible human health impacts. The 19 reregistered pesticides have been cleared for use. Two hundred fifty (250) other compounds are currently undergoing similar treatment. The Clinton Administration in 1994 began implementing new legislation in which chemical companies have to show that pesticides will not pose a health threat, and repeat the proof 15 years later when they are being reregistered. The current situation in which the U.S. EPA has to prove that the chemicals are detrimental to human health, will thus be altered considerably.

The PVC Problem

Polyvinyl chloride (PVC or vinyl), a plastic that is inert, easy and cheap to produce, and has hundreds of uses, may even create pollution problems. Products manufactured from this plastic include vinyl siding, gutters, window frames, pipes, floor tiles or coverings, furniture, clothing, toys, buckets, packaging, and electrical wire coatings. How could anyone find a problem with this innocent-looking plastic?

Greenpeace wants the manufacture and use of PVC phased out, because the process of manufacturing it creates many harmful substances. In Germany and Austria, city and town planners have created new construction policies that favor non-use of plastics in their new buildings. PVC combustion at low temperatures is similar to burning in inefficient waste incinerators, which produces toxic substances such as dioxins and furans. In addition, if fires occur in public buildings, melting plastic could fall on people.

In addition, few useful products can be manufactured from pure PVC. Additives are mixed with it, depending on the final use of the product. Therefore, only a fraction (1% currently) of the total amount of PVC produced can be easily recycled. Any products that are, usually are down-cycled — that is, manufactured into a product that is less valuable than the original commodity (i.e., rug backing). The Vinyl Institute, in New York, aims at increasing this recycling rate to 25%, but admits that economics will be a crucial factor in reaching this goal.

Further Developments

Other national and international organizations have examined the use of chlorine and its impacts on health and wildlife. One such organization is the International Joint Commission (IJC), the U.S.-Canadian agency that is an environmental 'watchdog' for the Great Lakes. (IJC responsibilities include the collation, collection, analysis, and distribution of data; advising and recommending actions to various environmental protection agencies; investigating various issues relevant to the Great Lakes basin ecosystem; and informing and educating the public about the Great Lakes ecosystem.) It called for the gradual phase-out of the use of chlorine and chlorine-containing compounds in industry — a Virtual Elimination Strategy. In a 1993 report published by the IJC, the organization stated that "even though many of the [chlorinated organics] have not been proven to be individually toxic, there is a growing body of evidence that these compounds are at best foreign to maintaining ecosystem integrity and quite probably persistent and toxic and harmful to health....Thus, it is prudent, sensible, and indeed necessary to treat these substances as a class rather than as a series of isolated individual chemicals." A 1994 amendment to the U.S. Clean Water Act suggested more definite recommendations on a national scale that could have an important influence on the proposal from the IJC.

Some of the Canadian provinces have set reduction limits for chlorine content of effluent from paper and pulp production. The use of the chemical will eventually be phased out completely by the Canadian paper and pulp industry.

In September of 1992, the Paris Commission, the European equivalent of the IJC that regulates emissions of pollutants into the northeast Atlantic Ocean, called for similar action. It recommended that discharges of organochlorines be reduced immediately and phased out gradually. Sweden has set similar goals for its paper and pulp industry. Use of plastics in public buildings will be phased out in Germany and Austria. Use of certain chlorinated chemicals, such as atrazine (a heavily used herbicide in the U.S.), is restricted in the Netherlands, Germany, northern Italy, and several Nordic countries.

In addition to these governmental actions, national and international environmental organizations such as Sierra Club, Pollution Probe of Canada, and Greenpeace are also calling for an immediate reduction in the use of chlorine and the eventual phase-out of its use.

As these chemicals and products are still present in the environment and in use by industry and the general public (how much PVC do you use every day?), it is likely that such problems will continue and may increase in the future.

Chlorine Industry's Response

The chlorine industry believes that a total chlorine ban is unwarranted. It states that many of the medical fears are unfounded as researchers have based their evidence on a few selected organochlorines, i.e., DDT and PCBs, many of which have been phased out of use or banned. Present compounds in use do not accumulate in the environment, have high-water solubilities, and are not persistent. Also, the total ban does not take into account the fact that a certain level of chemical concentration has to be reached before any adverse impact occurs.

Some industry officials believe that the scientific evidence used by researchers calling for the ban is questionable, misleading, and socially irresponsible. They point to the recovery of the Great Lakes signaled by the low levels of contaminants in fish and their increased consumption. They also state that other toxic chemicals in fish from the Great Lakes, heavy metals (mercury) for instance, create the same risk for people as organochlorine compounds and may not be distinguishable from them. They perceive the link between cancers and organochlorines to be more tenuous than other researchers have stated.

Industry officials also speculate on the future quality of human drinking water if chlorine is banned. The chlorination of the public's drinking water and waste water could be in serious jeopardy. The addition of chlorine to drinking water and sewage destroys many types of microorganisms that can create serious health problems and diseases. While this accounts for only 1% of the nation's chlorine use, it saves up to 25,000 lives per year. A total discharge ban would have an incredible impact on this aspect of public health and safety.

Instead of a total ban, the industry would prefer the standard assessment procedures to continue. This involves a case-by-case approach to the testing and subsequent regulation or banning of specific substances, rather than a total ban on a group of chemicals. In this way, the industry would have time to re-equip and devise new processes for the manufacture of replacements for the chemicals.

Chlorine Ban/Clean Water Act Amendment Policy and its Interpretation

United States: If the proposed amendment (Zero Discharge Act) were to become part of the U.S. Clean Water Act, or if the IJC were successful in establishing a Virtual Elimination Strategy, then the discussion on the treatment of chlorinated compounds individually or as a class will become more intense. In addition, once the amendment or ban is passed by the federal government, regulations must be formulated by the agency enforcing it. Formation of the regulations is a lengthy process with numerous stages involving several groups. The agency is then responsible for the enforcement of the regulations.

Policy that evolves from the amended law or ban results from the interpretation of the language and the definition of the terms used in the law/ban and the subsequent regulations. The terms and words need to be defined so that the broad goals or intent of the law can be enacted. For example, some environmentalists worry that the word 'zero' may be redefined to 'some,' 'almost,' 'virtual,' or a limit may be placed on the amount of pollutants released into the water. Such redefinitions occur sometimes as a compromise in the negotiations leading to passage of the law/ban. If industries violate the new law or ban, the enforcement agency may take them to court. Judges will decide the outcome of such cases based on the language of the law and the definition of the terms used in the regulations.

In 1993 the International Joint Commission produced documents on *A Strategy for Virtual Elimination of Persistent Toxic Substances*, which contain viewpoints from different sectors of the community on the proposed strategy. If the strategy is adopted, a similar process in the definition of terms and formulation of regulations for the Great Lakes states (and provinces) would be followed as in the amendment to the Clean Water Act.

Canada: In Canada, the federal government has the power to develop regulations to ensure the virtual elimination of persistent toxic chemicals. The Canadian Environmental Protection Act (CEPA) gives the Ministries of the Environment and National Health and Welfare considerable powers. The 1993 review of the Act examined the incorporation of a pollution prevention plan into this legislation or other federal statutes. However, unlike the U.S., any new comprehensive virtual elimination strategy will have to be a cooperative venture in Canada between the provincial and federal governments.

In Ontario, clean water regulation falls under the Municipal Industrial Strategy for Abatement (MISA) program within the provincial Environmental Protection Act (EPA RSO [Revised Status Ontario] 1990, C. E. 19). MISA, as the name suggests, is divided into two areas — municipal and industrial. Specific regulations for the former area are still under development. The industrial area is categorized into nine different sectors. Only two of the nine sectors currently have Limits and Monitoring Regulations. These industries, the petroleum and the pulp and paper industries, have specific limits on the quality of effluent discharged and also have a new monitoring system. The other seven sectors have monitoring regulations only, effluent standards are currently being developed (1994). Once the Limit and Monitoring Regulations have been developed for a sector, they supersede all existing monitoring regulations.

For the pulp and paper industries, MISA became law on November 25, 1993 (Effluent Monitoring and Effluent Limits — Pulp and Paper Sector Regulation 760/93). The objective of this legislation is the virtual elimination of persistent toxins in the discharges from pulp and paper mills to the province's rivers and lakes. This will have a direct impact on the water quality of the Great Lakes, as six of the province's 26 pulp and paper mills discharge their effluents directly into the Great Lakes basin.

Compiled by Tony P. Murphy for the
Ohio Sea Grant Education Program, 1995.

What can we learn about water quality in a river?

There are many rivers that flow into the Great Lakes. With each river, the lakes not only replenish their water but increase their load of sediments, dissolved salts, chemical pollutants, and living organisms. At the places where the rivers become part of the Great Lakes, they tend to lose their individual identities, but as rivers they have a special character of their own. A river is the producer and the product of its *watershed*, the area which it drains. The river's physical attributes, the chemical properties of its stream bed, the living things in and around it, and the human developments on its banks contribute to the quality of its water. In turn, the river's water quality influences that of the Great Lake into which it flows.

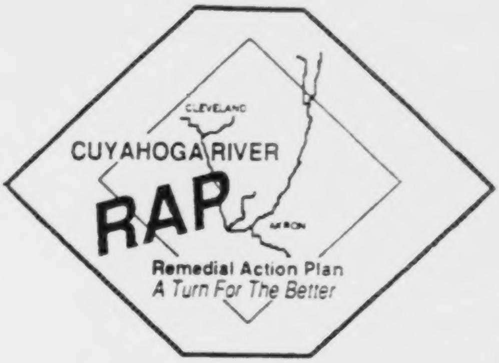
This is an investigation that can be modified to deal with almost any river in the Great Lakes region. In it, you will examine the data sources for learning about one sample river, the Cuyahoga in Cleveland, and for comparison the Black River in Michigan. As you find and use the data sources about the Cuyahoga and Black, class teams will look up the same information about other rivers for comparison. Contact your state's or province's natural resources agency to see if any organizations are monitoring your selected rivers for water quality. Perhaps your class can contribute to those efforts.

OBJECTIVES

When you have completed this activity you will be able to:

- Describe some physical characteristics of a local river and its watershed.
- Investigate the types of tests used to monitor rivers.
- Compare the water quality among some rivers in the Great Lakes basin.
- Compare the water quality in a local river with state standards for water quality.
- Compare several rivers on the basis of their pollution input to your Great Lake.

Figure 1. Cuyahoga River Rap



Source

Adapted from OEAGLS EP-05: *How to protect a river*, by Donald L. Hyatt, Beth A. Kennedy and Victor J. Mayer.

Earth Systems Understandings

This activity deals with ESU 3 (science processes) to investigate interacting subsystems (ESU 4) and aspects of human impacts (ESU 2) that influence the subsystems.

Materials

- Internet access or a recent copy of the U.S. Geological Survey publication titled *Water Resources Data for Ohio* (or your state), *Water Year 1996* (or current year). There may be a specific volume for the Great Lakes watershed.
- *Field Manual for Water Quality Monitoring*, by M. Mitchell and W. Stapp, University of Michigan, 1992, or instructions from water testing kits (optional).
- Generalized map of the watersheds for the Cuyahoga River, Ohio, and Black River, MI.
- Laminated topographic quadrangles from three sites along the Cuyahoga River, Black River and/or your rivers.

See: http://h2o.usgs.gov/swr/ to access maps and other data from monitoring sites.

PROCEDURE

1. Locate the Black River on the map of rivers entering Lake Huron. In which direction does the river flow? List several major cities or other landmarks from the source of the river to its mouth.

2. Obtain the topographic map that has the source of the Black River on it, and the one that has the mouth, where it enters the lake. What is the approximate elevation of the source of the river? The mouth? What is the distance from source to mouth?

3. Calculate the slope of the river by dividing its length into the difference in elevation from source to mouth. The formula is:

   (source elevation - elevation at mouth)/length

   The slope is generally expressed as elevation per mile (kilometer). A low slope means the river flows slowly overall. Identify areas along the river where the slope is greater. What is the comparative speed of the river at those places?

4. How many streams enter the river along its length? These are its tributaries. Name the major ones. Describe the topography along the river and its tributaries.

5. Using a water-soluble marker, outline the *watershed* of the river (the entire region where the river and its tributaries collect water). Use your math skills to determine the approximate area of the watershed (for comparison purposes only).

6. Repeat steps 1 through 5 with the Cuyahoga River in Ohio. What similarities and differences are there between the two rivers, i.e., size of cities nearby, topography, etc.? Select a river near your school and investigate its characteristics. Repeat steps 1 through 5 for your river. Compare the rivers you have studied.

Different aspects of river quality are important. Three types of monitoring are: physical monitoring, biological monitoring, and organic chemical monitoring. You will investigate two types of water quality monitoring. Testing for organic chemicals requires equipment not usually available to schools.

Answers

1. Cities along the Black River include Croswell, Jeddo, and Port Huron. Near the mouth of the river, where it drains into Lake Huron, is an international boundary between the U.S. and Canada.

Teacher's Note

Maps need to be laminated so that students can outline the watershed and the activity can be repeated by others.

Landmarks along the Cuyahoga River include Cleveland, Cuyahoga Valley National Recreation Area, Akron, and Cuyahoga Falls.

Students may want to do an Internet search to determine populations of cities along the rivers.

PHYSICAL MONITORING

Physical monitoring can include several of the following tests:

Dissolved oxygen – the oxygen available in the water; higher levels are associated with healthier rivers.

Fecal coliform – *Escherichia coli* or *E. coli*; bacteria found in human and animal feces; fecal coliforms are normal organisms assisting in human digestion. The presence of *E. coli* in water indicates contamination by sewage, and high numbers indicate that other pathogenic organisms might also be active.

pH – measures the H+ ions in water; a one unit change in pH corresponds to a ten-fold change in the acidity of the water. Organisms are accustomed to a moderately narrow pH range, so changes in pH can affect which ones can survive. Extreme values on the scale prevent living things from surviving in the river.

Biochemical oxygen demand (BOD) – shows the amount of oxygen used by aerobic microorganisms in breaking down organic matter; higher BOD levels indicate that oxygen is being used readily by aerobic bacteria and is unavailable to other organisms.

Temperature – water temperature can affect other characteristics such as dissolved oxygen, because cooler water can hold more oxygen than warmer water.

Phosphates – phosphorus is a nutrient that is active in growth and metabolism of plants and animals. Excess phosphates may cause an abundance of algae in the water and lead to accelerated eutrophication.

Nitrogen – it is a building block for protein and is more plentiful than phosphorus in ecosystems; ammonia, nitrates, and nitrites are some of its forms. Nitrogen can also accelerate eutrophication.

Turbidity – water clarity is affected by suspended solids; the amount of turbidity affects water temperature because sediments absorb the sun's heat. Turbidity also relates to the amount of light entering the water and affecting photosynthesis and oxygen levels. Sediments can also cover eggs of fish and insects and make aquatic habitats less suitable for organisms.

Total Solids – measures both dissolved and suspended particles in water. Too high or too low levels of solids in water can affect organisms by limiting growth and/or affecting nutrient and water transport to and from cells.

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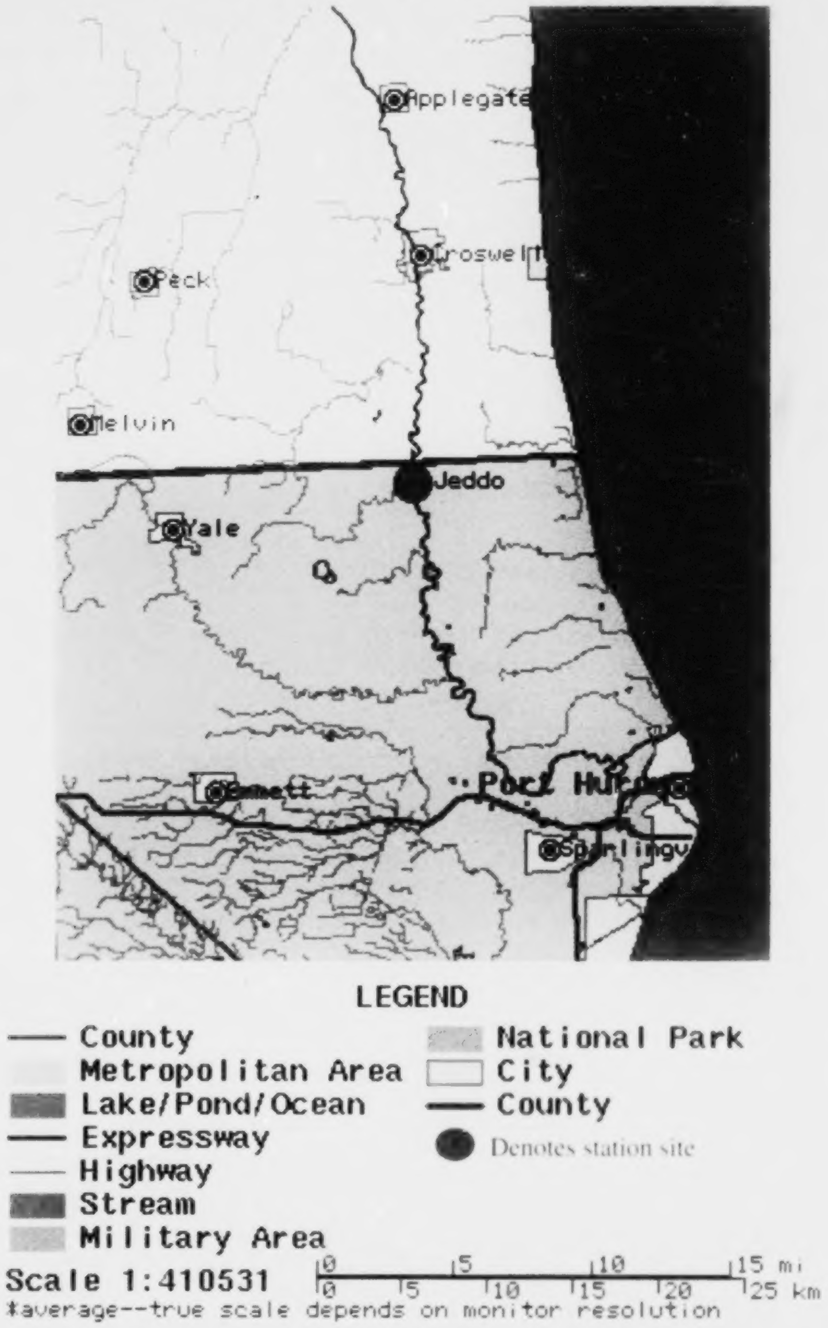
7. Create a concept map using the nine types of physical tests discussed. Show how the results of one test may influence the results of others. For example, high nitrates accelerate eutrophication, which increases turbidity and lowers oxygen levels. Explore other relationships and illustrate them in your diagram.

The river and its tributaries collect things besides water as they flow toward the lake. In Maps 1 through 3, cities and other features are shown that can affect water quality. How do you think river quality changes depending on where the river flows?

Map 1. Region Surrounding Black River Near Jeddo, MI.


Applegate
Croswel
Peck
Melvin
Jeddo
Yale
Emmett
Port Huron
Sparlingv
LEGEND
County
Metropolitan Area
Lake/Pond/Ocean
Expressway
Highway
Stream
Military Area
National Park
City
County
Denotes station site
Scale 1:410531
0 5 10 15 mi
0 5 10 15 20 25 km
*average--true scale depends on monitor resolution

Source: U.S. Geological Survey. Map of region surrounding Black River near Jeddo, MI. [Online] Available http://h2o.usgs.gov/swr/MI/data_modules/nmdmap.cgi?statnum=04159492&ht=0.5. Map provided by U.S. Census Tiger Mapping Server.

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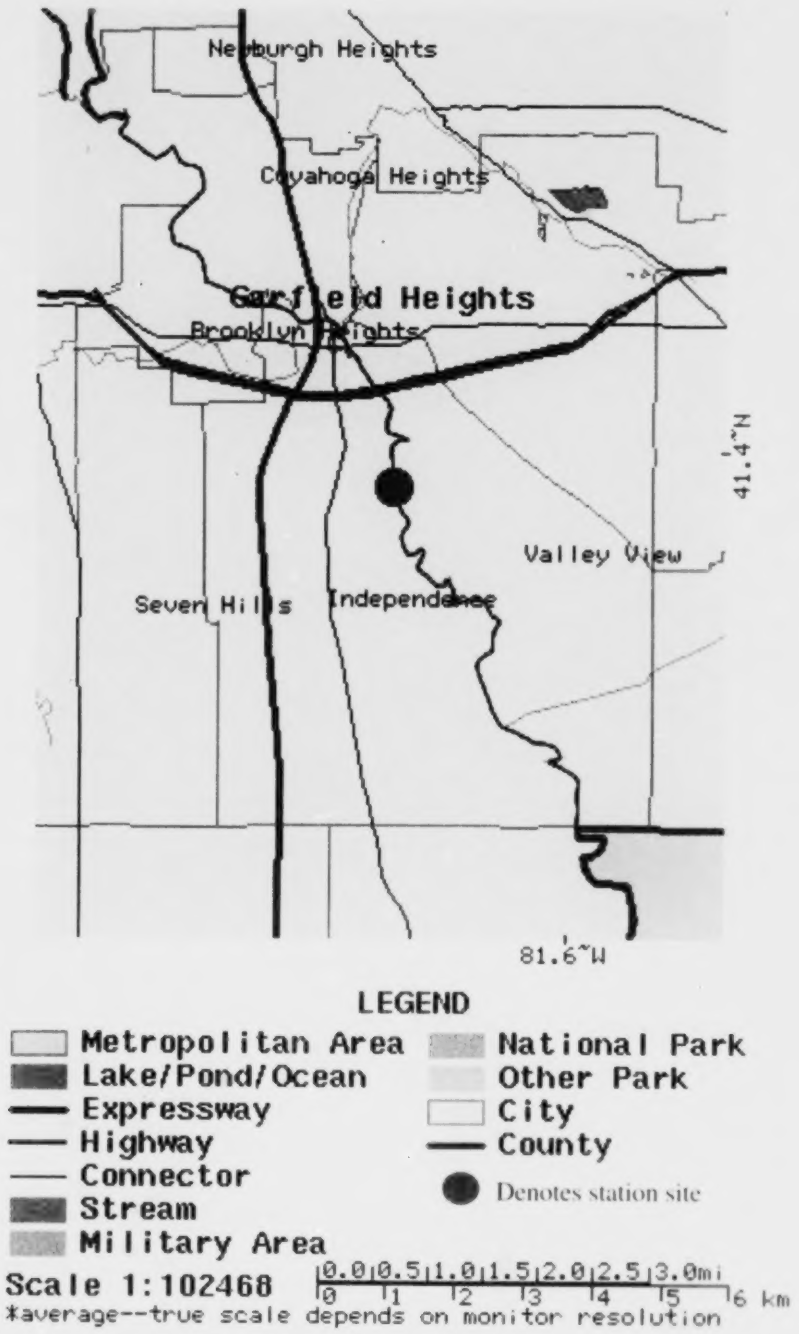
Map 2. Region Surrounding Cuyahoga River at Independence, Ohio.


Newburgh Heights
Cuyahoga Heights
Garfield Heights
Brooklyn Heights
41.4°N
Valley View
Seven Hills
Independence
81.6°W
LEGEND
Metropolitan Area
Lake/Pond/Ocean
Expressway
Highway
Connector
Stream
Military Area
National Park
Other Park
City
County
Denotes station site
Scale 1:102468
0.0 0.5 1.0 1.5 2.0 2.5 3.0mi
0 1 2 3 4 5 6 km
*average--true scale depends on monitor resolution

Source: U.S. Geological Survey, Map of region surrounding Cuyahoga River at Independence, Ohio. [Online] Available http://h2o.usgs.gov/swr/OH/data.modules/nmdmap.cgi?statnum=04208000. Map provided by U.S. Census Tiger Mapping Server.

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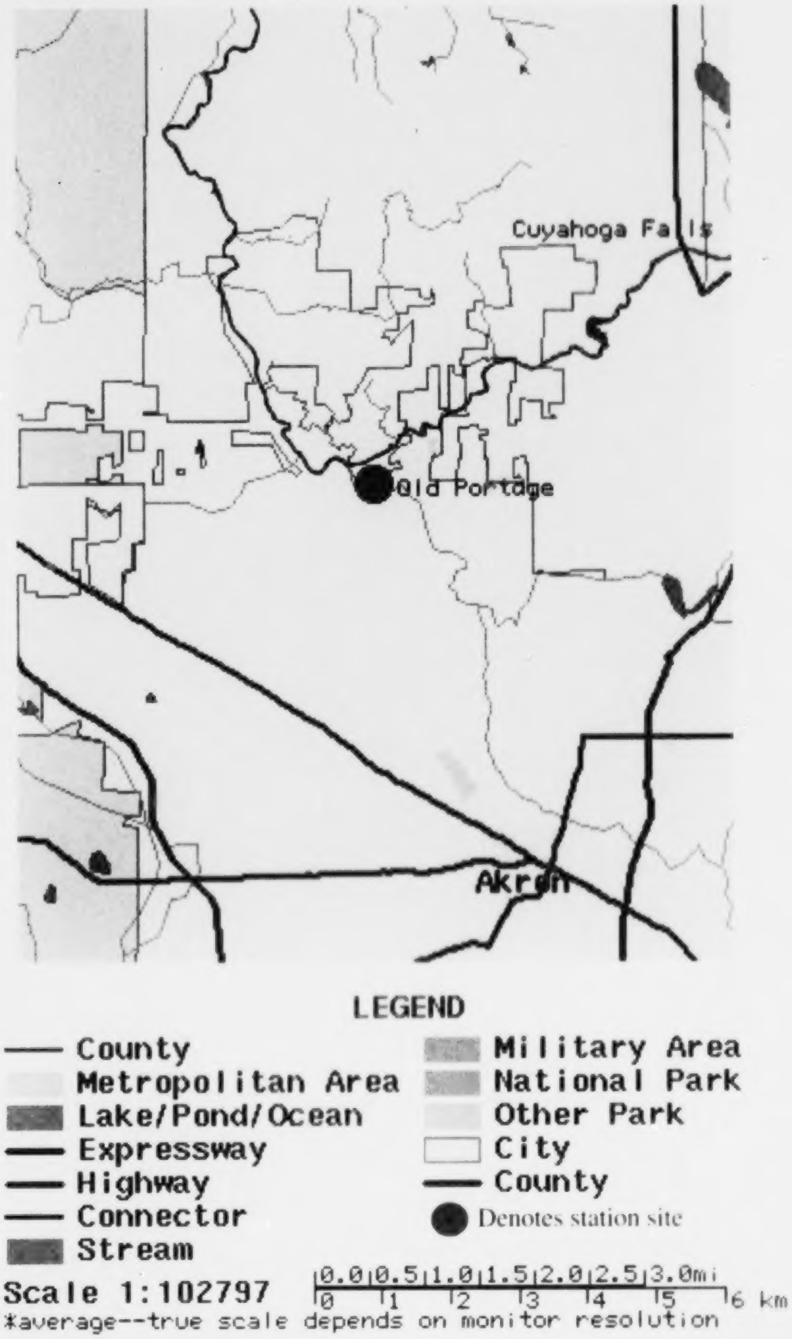
Map 3. Region Surrounding Cuyahoga River at Old Portage, Ohio.


Cuyahoga Falls
Old Portage
Akron
LEGEND
County
Metropolitan Area
Lake/Pond/Ocean
Expressway
Highway
Connector
Stream
Military Area
National Park
Other Park
City
County
Denotes station site
Scale 1:102797
0.0 0.5 1.0 1.5 2.0 2.5 3.0mi
0 1 2 3 4 5 6 km
*average--true scale depends on monitor resolution

Source: U.S. Geological Survey. Map of region surrounding Cuyahoga River at Old Portage, Ohio. [Online] Available http://h2o.usgs.gov/swr/OH/data.modules/nmdmap.cgi?statnum=04206000. Map provided by U.S. Census Tiger Mapping Server.

BEST COPY AVAILABLE

In the following tables are water quality measurements from two places along the Cuyahoga River in Ohio and one site along the Black River near Port Huron in Michigan. They were obtained from the U.S. Geological Survey. Obtain comparable data for the other river(s) you are investigating.

Teacher's Note

Students can consider the seasonal changes in the data. For example, the earliest reading taken in spring should occur when melting snow and rain cause high water and rapid flow. Some summer readings will occur when the river has relatively low flow.

The USGS has several Web sites. Begin with http://h2o.usgs.gov/swr/ and find out more information, including regional maps of monitoring sites closest to your school.

Table 5 with the State of Ohio water quality standards is also included. States set standards in order to meet national requirements under U.S. EPA. Students may want to obtain standards for Michigan. When states monitor water quality, they use U.S. recommendations, U.S. criteria, and state rules. State agencies may issue permits to discharge for industries. Decisions are based on the quality of the river and how much additional pollution they deem the water can withstand. Permits limit the quantity of pollutants going into rivers. Ambient monitoring involves ongoing investigation of surface water quality in rivers.

8. What is meant by water quality?

9. Are there any differences in water quality between the monitoring stations?

10. In the Great Lakes region are several Areas of Concern. The Cuyahoga River is one of them. Do research to obtain a list of the materials found in the Black River and Cuyahoga River that are concerns affecting water quality based on standards for those materials. Consult the Internet about the materials, or read about them in the *Manual for Water Quality Monitoring*.

Two internet sites provide much information:
www.cciw.ca/glimr/gl-programs/RAPs/intro.html
www.great-lakes.net:2200/envt/water/watqual/managl/rap

11. What can be done to correct these possible problems of water quality? Spend some time discussing this with your class.

INVESTIGATING THE DATA

1. Are there differences between summer and spring readings at a specific site? Between fall and summer readings? If so, what could cause the differences?

2. Compare the data from 1985-86 for the two sites along the Cuyahoga River – Old Portage and Independence (Tables 2,

Teacher's Note

1. Students can discuss climate and seasonal changes and the differences they note in water quality measurements throughout the year.

3). You may want to graph the data for a visual comparison. How do the data differ? How can you explain the differences or similarities?

2. Compare the 1985-86 figures (Table 2) with those for 1990-91 (Table 1) at the Independence site? How do the data compare between the years shown? Do the data suggest changes in the water quality of the river?

3. Compare the data for the beginning, middle and end of the month. Choose one parameter and graph the data by month. Do you observe any trends? What do the trends, if any, suggest about monthly changes in a river?

Table 1. Cuyahoga River at Independence Ohio, 1990-1991.

pH. WATER, WHOLE, FIELD, STANDARD UNITS, WATER YEAR OCTOBER 1990 TO SEPTEMBER 1991, DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	8.0	7.9	8.1	7.9	8.0	---	8.2	8.0	7.9	8.4	8.3	8.1
15	7.8	8.0	7.9	8.0	7.9	7.9	7.9	8.0	8.4	8.2	8.1	8.1
28	7.9	7.9	---	8.0	7.9	8.1	8.0	7.8	8.6	8.3	8.2	8.4
MEAN	7.8	8.0	---	---	---	---	8.0	8.0	8.3	---	---	8.1
MAX	8.0	8.1	---	---	---	---	8.4	8.2	8.6	---	---	8.4
MIN	7.7	7.8	---	---	---	---	7.8	7.8	7.9	---	---	7.8

OXYGEN DISSOLVED (MG/L), WATER YEAR OCTOBER 1990 TO SEPTEMBER 1991, DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	9.0	10.0	11.3	---	13.4	---	12.2	9.3	6.1	8.8	8.5	8.0
15	9.0	10.8	12.0	13.2	12.6	12.6	10.3	8.2	9.1	7.2	8.4	7.9
28	9.9	9.8	---	13.0	13.2	11.0	9.9	6.4	8.5	8.6	8.4	9.5

WATER TEMPERATURE. DEGREES CELSIUS, WATER YEAR OCTOBER 1990 TO SEPTEMBER 1991, DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	16.5	12.5	7.0	2.5	1.5	---	9.0	18.0	25.5	25.5	23.5	23.0
15	15.0	8.0	5.5	3.0	2.5	6.0	12.0	23.0	24.5	23.0	22.5	23.5
28	10.5	11.5	---	2.0	3.5	11.5	16.0	23.0	25.5	22.0	25.0	14.0

4. Do you detect a relationship between any two of the parameters? Graph temperature data and dissolved oxygen data. What do the data suggest about the relationship between the two parameters in a river?

5. Do any of the data reveal measurements outside of the limits specified by Ohio's Surface Water Quality Standards?

6. Discuss the range of pH values given as Ohio's Surface Water Quality Standards in Table 5. In your view is the range too wide? Too narrow? Design an investigation to assess the impact of the extremes of allowable pH.

Answer

5. Some of the minimum levels of dissolved oxygen in the Cuyahoga at Old Portage 1985-1986 were out of range of the criteria for exceptional warmwater and coldwater habitats, i.e., October and August. Temperature data are beyond the upper (warmer) range limits for certain months, i.e., April at the Independence site, 1985-1986, and others.

Table 2. Cuyahoga River at Independence Ohio, 1985-1986.

pH. WATER, WHOLE, FIELD, STANDARD UNITS, WATER YEAR OCTOBER 1985 TO SEPTEMBER 1986, DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	8:4	8.3	7.8	8.0	7.9	7.9	8.5	8.1	7.8	7.9	8.3	8.2
15	8.0	7.9	7.8	8.0	7.9	7.7	8.0	7.8	7.7	7.9	8.0	8.2
28	8.2	7.8	8.0	7.9	7.9	8.1	8.4	7.6	7.6	8.3	8.1	7.6
MEAN	8.2	7.9	7.9	7.9	7.8	7.9	8.2	7.9	7.8	8.0	8.1	8.0
MAX	8.5	8.3	8.0	8.1	7.9	8.4	8.6	8.5	8.0	8.3	8.4	8.3
MIN	7.9	7.8	7.8	7.7	7.7	7.7	7.8	7.6	7.6	7.6	7.9	7.6

OXYGEN DISSOLVED (MG/L), WATER YEAR OCTOBER 1985 TO SEPTEMBER 1986, DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	7.7	8.5	10.9	12.6	11.8	13.0	11.9	8.5	6.8	8.7	8.5	9.2
15	---	9.9	12.4	14.2	11.8	11.6	9.9	8.1	7.2	7.7	7.6	9.2
28	9.7	10.9	12.2	11.4	13.0	11.8	8.8	7.6	7.1	8.2	8.8	6.0

WATER TEMPERATURE, DEGREES CELSIUS, WATER YEAR OCTOBER 1985 TO SEPTEMBER 1986, DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	17.5	13.5	8.5	3.0	3.0	2.0	14.5	17.0	24.0	20.5	24.5	20.5
15	17.0	12.0	2.0	1.0	2.5	6.5	13.5	20.0	23.0	23.5	24.5	19.5
28	13.0	8.0	1.5	.5	2.0	9.5	19.5	20.0	23.0	25.5	20.0	22.0

Table 3. Cuyahoga River at Old Portage Ohio, 1985-1986.

pH. WATER, WHOLE, FIELD, STANDARD UNITS, WATER YEAR OCTOBER 1985 TO SEPTEMBER 1986, DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	8.2	7.9	7.9	8.1	8.0	8.0	8.3	8.0	7.9	7.9	8.0	8.0
15	7.9	7.8	8.0	8.2	8.1	7.9	8.1	7.8	7.9	7.9	7.8	7.9
28	7.9	7.9	8.0	8.0	8.0	8.2	8.2	7.8	7.8	8.0	8.0	7.9
TOTAL	244.4	235.2	248.5	250.4	222.9	249.1	245.1	245.2	235.2	243.3	243.2	235.4
MEAN	7.9	7.8	8.0	8.1	8.0	8.0	8.2	7.9	7.8	7.8	7.8	7.8
MAX	8.2	7.9	8.1	8.2	8.1	8.3	8.4	8.2	8.0	8.0	8.0	8.0
MIN	7.6	7.7	7.9	7.9	7.9	7.9	8.0	7.7	7.7	7.6	7.6	7.7
MED	7.9	7.8	8.0	8.1	8.0	8.0	8.2	7.9	7.8	7.8	7.8	7.8

OXYGEN DISSOLVED (MG/L), WATER YEAR OCTOBER 1985 TO SEPTEMBER 1986, DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	7.1	9.0	11.5	12.2	13.1	13.4	12.0	8.1	7.6	7.7	8.2	8.7
15	7.2	10.9	13.3	12.2	13.4	12.5	9.6	7.2	8.2	7.6	6.5	7.5
28	9.0	11.5	12.7	13.5	13.4	11.9	10.0	7.7	7.3	7.7	7.9	7.6
TOTAL	238.0	322.8	383.0	385.1	371.3	389.4	317.4	244.6	229.0	232.6	217.6	220.1
MEAN	7.7	10.8	12.4	12.4	13.3	12.6	10.6	7.9	7.6	7.5	7.0	7.3
MAX	9.4	11.8	13.3	13.7	13.7	13.7	12.0	9.6	8.5	8.3	8.5	8.7
MIN	5.4	8.3	11.5	11.5	12.7	11.6	8.9	6.4	6.3	6.4	5.3	6.2
MED	7.7	11.0	12.3	12.1	13.3	12.5	10.7	7.8	7.7	7.6	6.9	7.3

WATER TEMPERATURE. DEGREES CELSIUS, WATER YEAR OCTOBER 1985 TO SEPTEMBER 1986, DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	17.0	12.5	7.0	2.0	2.5	2.0	14.0	18.5	22.5	21.5	24.5	19.5
15	18.0	11.0	1.5	1.5	2.0	5.5	14.0	20.5	22.0	23.5	24.0	20.5
28	13.0	7.5	.5	1.0	2.0	10.0	19.0	20.5	23.0	26.0	21.5	22.5
TOTAL	510.0	297.0	94.5	69.0	66.0	180.5	418.5	597.5	678.0	767.5	722.0	651.0
MEAN	16.5	9.9	3.0	2.2	2.4	5.8	13.9	19.3	22.6	24.8	23.3	21.7
MAX	19.5	13.0	7.0	3.5	4.0	13.0	19.0	23.0	25.0	28.5	25.0	24.0
MIN	12.5	6.5	.5	1.0	1.5	2.0	11.0	15.5	21.0	20.5	20.0	18.5
MED	17.0	9.7	2.0	2.0	2.2	5.0	13.7	19.5	22.5	25.0	24.0	21.7

Table 4. UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY BLACK RIVER NEAR JEDDO, MI.

DATE	TIME	OXYGEN, DISSOLVED (MG/L)	COLIFORM, FECAL, COLONIES/ 100 ML	PH OF WATER (STANDARD UNITS)	TEMPERATURE OF WATER (DEG C)	PHOSPHORUS TOTAL (MG/L)	NITROGEN, AMMONIA + ORGANIC TOTAL (MG/L)	NITROGEN, NO2+N03 DISSOLVED (MG/L)	SOLIDS, RESIDUE AT 180 DEG. C DISSOLVED (MG/ L)
04-03-96	1100	12.8	K26	8.2	4.0	0.120	1.1	3.60	334
05-03-96	1310	10.6	K110	8.2	9.0	0.170	1.1	6.70	464
05-16-96	1200	10.4	280	8.3	12.0	0.060	1.1	5.70	482
06-06-96	1210	8.7	K1000	8.3	16.5	0.240	1.9	4.50	412
06-19-96	1520	7.2	>600	8.0	17.5	0.310	1.9	7.00	252
07-11-96	1230	8.3	K1300	8.4	20.0	--	--	--	498
08-13-96	1440	9.0	68	8.4	23.0	0.020	0.70	1.10	511
09-11-96	1150	7.7	1500	8.3	20.5	--	--	--	404

Table 5. Ohio's Surface Water Quality Standards.
Numerical and narrative criteria for Aquatic Life Habitat and Water supply use designation. All values are expressed as total concentration unless specified otherwise.

		Use Designations					
		Aquatic Habitat				Water Supply	
Parameter	Units	Warmwater Habitat	Exceptional Warmwater Habitat	Coldwater Habitat	Limited Resource Water	Public Water Supply	Agricultural Water Supply
Dissolved Oxygen (Outside Mixing Zone – Minimum at any time)	mg/l	4.0	6.0	6.0	2.0		
Dissolved Solids (Outside Mixing Zone)							
Maximum	mg/l					750[e]	
30-day average	mg/l	1500[d]				500[e]	
Nitrate–N (Outside Mixing Zone – Human Health 30-day average)	mg/l					10	
Nitrates + Nitrites (Outside Mixing Zone – 30-day average)	mg/l						100
pH (Outside Mixing Zone)	s.u.	6.5-9.0	a	a	6.5-9.0[b]		
Phosphorus (Inside mixing zone)							
Maximum		c					
Human Health 30-day average						c	
Temperature (Outside Mixing Zone)							
Maximum	F (°C)	Table 2	f	f	98 (37)		
30-day average	F (°C)	Table 2	f	f	94 (34)		

Notes: For the purposes of setting water quality based effluent limits, the criteria which apply "Outside Mixing Zone" shall be met after the effluent and the receiving water have been determined to be reasonably well mixed based upon information readily available to the director (of the OEPA) . . . The limited resource water criteria represent the minimum water quality to be met in all surface waters of the state outside the mixing zone.

"Warmwater" – these are waters capable of supporting and maintaining a balanced, integrated adaptive community of warmwater aquatic organisms . . . "Exceptional warmwater" – these are waters capable of supporting and maintaining an exceptional or unusual community of warmwater aquatic organisms . . . "Coldwater" – are waters capable of supporting populations of coldwater fish and associated vertebrate and invertebrate organisms and plants on an annual basis . . . "Limited resource water" – these are waters that have been the subject of a use attainability analysis and have been found to lack the potential for any resemblance of any other aquatic life habitat as determined by the biological criteria . . . to this rule (3745-1-07 – Ohio Water Quality Standards).

Water supply "Public" – these are waters that, with conventional treatment, will be suitable for human intake and meet federal regulations for drinking water . . . "Agricultural" – these are waters suitable for irrigation and livestock watering without treatment.

[a] pH is to be 6.5-9.0, with no change within that range attributable to human-induced conditions.

[b] Acid mine drainage streams over sandstone geotype are exempt from the pH criterion.

[c] Total phosphorus as P shall be limited to the extent necessary to prevent nuisance growths of algae, weeds, and slimes that result in a violation of the water quality criteria set forth in Chapter 3745-1-04 (E) of the Ohio Administrative Code or, for public water supplies, that result in taste or odor problems. In areas where such nuisance growths exist, phosphorus discharges from point sources determined significant by the Ohio environmental protection agency shall not exceed a daily average of one milligram per liter as total P, or such stricter requirements as may be imposed by the Ohio environmental protection agency in accordance with the International Joint Commission (United States-Canada agreement).

[d] Equivalent 25°C specific conductance value is 2400 micromhos/cm.

[e] Equivalent 25°C specific conductance values are 1200 micromhos/cm as a maximum and 800 micromhos/cm as a 30-day average.

[f] At no time shall the water temperature exceed the temperature which would occur if there were no temperature change attributable to human activities.

Table 6. Ohio's Surface Water Quality: Temperature Criteria.
Cuyahoga River – Headwaters of the Cuyahoga River Gorge Dam Pool to the Cuyahoga River Ship Channel. Shown as degrees Fahrenheit and (Celsius).

	Jan. 1-31	Feb. 1-29	Mar. 1-15	Mar. 16-31	Apr. 1-15	Apr. 16-30	May 1-15	May 16-31	June 1-15
Average	45 (7.2)	45 (7.2)	51 (10.6)	53 (11.7)	55 (12.8)	60 (15.6)	65 (18.3)	71 (21.7)	80 (26.7)
Daily Maximum	49 (9.4)	49 (9.4)	55 (12.8)	57 (13.9)	62 (16.7)	66 (18.9)	70 (21.1)	78 (25.6)	84 (28.9)

	June 16-30	July 1-31	Aug. 1-31	Sept. 1-15	Sept. 16-30	Oct. 1-15	Oct. 16-31	Nov. 1-30	Dec. 1-31
Average	84 (28.9)	84 (28.9)	84 (28.9)	84 (28.9)	77 (25.0)	70 (21.1)	63 (17.2)	55 (12.8)	45 (7.2)
Daily Maximum	88 (31.1)	88 (31.1)	88 (31.1)	88 (31.1)	82 (27.8)	75 (23.9)	69 (20.6)	64 (17.8)	52 (11.1)

7. Examine data from the Black River near Jeddo, MI (Table 4). On what date were the highest nitrogen and phosphorus readings recorded? What could have caused the levels noted? What is the dissolved oxygen reading on that date, and how does it compare to other daily readings? Do you think there is a relationship between the three parameters? What kind of relationship would you predict based on the data? How would you test your hypothesis? Compare other parameters to discover any trends in the data.

N and P were highest June 19, 1996, and that was also the lowest reading for dissolved oxygen. Students may speculate on how nutrients affect dissolved oxygen, or consult p. 31. Explore other possibilities by asking scientists you know.

BIOLOGICAL MONITORING

Even if some water quality threats are present, there could still be living things in the river. Some scientists specialize in determining water quality by looking at its effects on stream *macroinvertebrates*. These are small but visible animals without backbones. Certain kinds can live only in very clean, unpolluted water and cannot tolerate even small levels of pollution. Other organisms are pollution tolerant, and they will be present in a stream regardless of its condition. Still others are somewhere between those extremes. Macroinvertebrates can do two things: they can serve as indicator species indicating pollution or absence of pollution, and they can demonstrate diversity of organisms in a stream – higher diversity suggesting healthier rivers.

Intolerant Species – will not be found in polluted rivers. Stoneflies require oxygen-rich water; thus, they are an intolerant species.

Facultative Species – can adapt to pollution in their environment; caddisflies, for example, increase pumping of their abdomen to take in more oxygen when there are low oxygen levels.

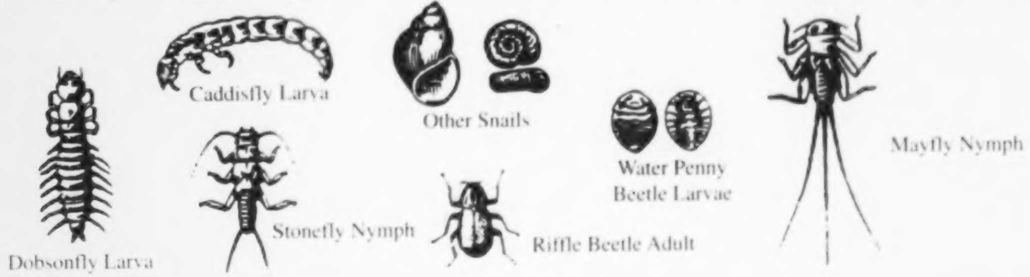
Tolerant Species – will be found in poor-quality and good-quality water. Some midges can survive with low oxygen levels, and aquatic worms (Oligochaeta) can tolerate high levels of silt and organic substances.

Macroinvertebrates are affected by the temperature of the water in a river, as warmer water tends to encourage their growth. The current strength, type of substrate on the river bottom, and the amount of food available also influence the survival of the organisms.

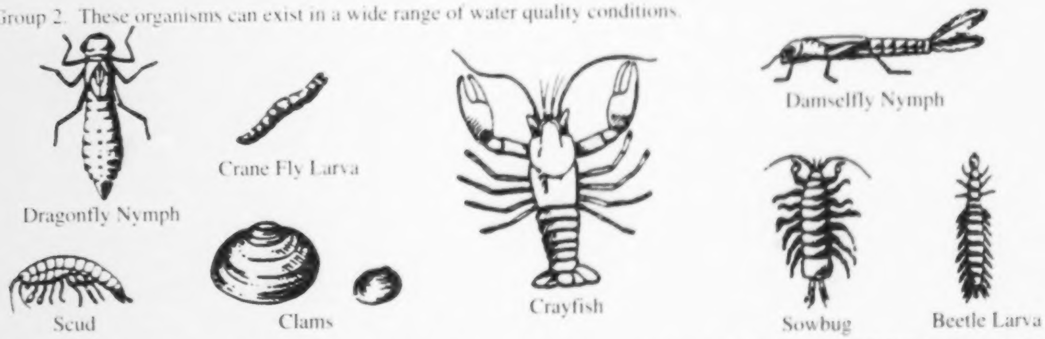
The chart on the next page shows what the macroinvertebrates are like for many parts of the Great Lakes region. If your class has the opportunity to actually test water quality in a stream, use the guidelines from your state or province, and take along a similar sheet to guide your counting of organisms.

The analyses that follow are similar to the ones you would perform using data from your local stream.

Group 1. These organisms are generally pollution intolerant. Their dominance generally signifies **GOOD WATER QUALITY**.


Caddisfly Larva
Other Snails
Water Penny Beetle Larvae
Mayfly Nymph
Dobsonfly Larva
Stonefly Nymph
Riffle Beetle Adult

Group 2. These organisms can exist in a wide range of water quality conditions.


Damselfly Nymph
Crane Fly Larva
Dragonfly Nymph
Crayfish
Scud
Clams
Sowbug
Beetle Larva

Group 3. These organisms are generally tolerant of pollution. Their dominance usually signifies **POOR WATER QUALITY**.

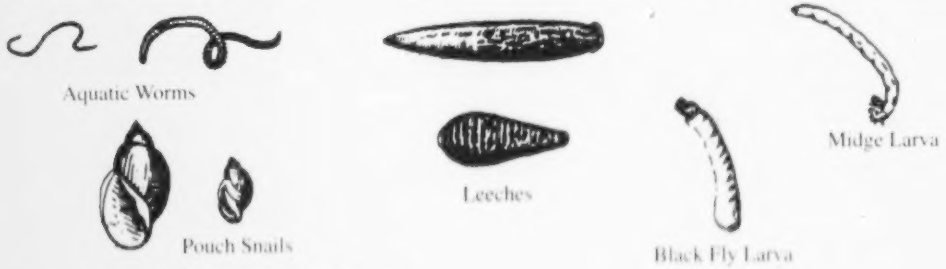

Aquatic Worms
Leeches
Midge Larva
Pouch Snails
Black Fly Larva

Figure 1. Macroinvertebrate Taxa Groups

Stream Assessment

To conduct stream asssessment observations and analysis, assign each group the following index values: Group 1 = 3, Group 2 = 2, Group 3 = 1. Count the number of types of organisms present from each category and multiply the group index value. Add the respective indexes for a cumulative index value.

Stream Quality Assessment	Cumulative Index Value
Excellent	23 and above
Good	17 – 22
Fair	11 – 16
Poor	10 or less

Example:
Group 1 taxa = caddisfly, stonefly and mayfly, 3x3 = 9; Group 2 taxa = dragonfly, crayfish, clam, 3x2 = 6; Group 3 taxa = blackfly, midge, 2x1 = 2. Cumulative index value = 17.

Source: Division of Natural Areas and Preserves, Scenic Rivers Section. 1993. *A Guide to Volunteer Stream Quality Monitoring*. Ohio Department of Natural Resources, Columbus, Ohio. 23 p.

Teacher's Note

Students may want to prepare a presentation for the class with the format used in the *Great Lakes Solution Seeker*, (CD-ROM), by the Ohio Sea Grant Education Program, 1996.

Cuyahoga River
Location: Lake Erie
State/Prov: Ohio
"The middle and lower sections of the Cuyahoga River are severely impacted by industrial and municipal discharges as well as by nonpoint urban runoff and combined sewer overflows. Sediment, biota, and water quality have all been impacted by pollution. In addition, the physical characteristics of the lower Cuyahoga have been severely altered due to extensive annual maintenance dredging and shoreline development."

Major industrial discharges from RM 10 to Lake Erie include LTD Steel and the DuPont and Harshaw Chemical Companies.
Types of Problems: Conventional pollutants, heavy metals, toxic organics, contaminated sediments, plant and wildlife, and aesthetics.

Sources of Problems: Municipal Point Sources, Industrial Point Sources, Urban Nonpoint, Combined Sewer Overflows (CSO), In-Place Pollutants.

Cleanup Information:
John Beeker, Secr.
Cuyahoga River RAP
Coordinating Committee
668 Euclid Ave. 4th Floor
Cleveland, Oh. 44115
(216)241-2414, ext. 250

Bob Wysenksi
Ohio EPA
2110 Aurora Road
Twinsburg, OH 44087
(216) 963-1161

Virginia Aveni, Public Participation Contact
Cuyahoga County Planning Commission
323 Lakeside Avenue West, Suite 400
Cleveland, OH 44113-1009
(216) 443-3700

Source: Fortner, R.W., Project Director; A. Lewandowski and Richard Meyer, Editors. 1996. *Great Lakes Solution Seeker*, (CD-ROM), Ohio Sea Grant Education Program.

1a. Assume the Black River was monitored for macroinvertebrates at two sites, with the following results. Determine a cumulative index value based on the data, using the methods included with Figure 1.

Site 1	**Site 2**
Group 1: stonefly, caddisfly, riffle beetle, mayfly	Group 1: none
Group 2: dragonfly, crayfish, damselfly, clams, crane fly	Group 2: sowbug, scud
Group 3: midge, pouch snails	Group 3: aquatic worms, midge, black fly, leech

Cumulative Index Value: Site 1 ______ Site 2 ______

Here is another way to determine water quality based on macroinvertebrates.

1b. Assume the Cuyahoga River was monitored for macroinvertebrates at two sites, with the following results in the accompanying table. Determine a composite score based on the data and tables. How would you rate the water quality at each site? What would you predict the chemical testing dataset might look like at the sites based on the macroinvertebrate results collected?

Site 1 – Stillwell Road	**Site 2 – Infirmary Road**
No. of Taxa: 61	No. of Taxa: 24
Density (no./m^2): 2400	Density (no./m^2): 900
S-G/D*: 1.2	S-G/D*: .01
A/I**: No isopods	A/I**: No isopods
Tolerance to Organic Pollution***	Tolerance to Organic Pollution***
Intolerant species: 72%	Intolerant species: 5%
Facultative species: 27%	Facultative species: 48%
Tolerant species: 1%	Tolerant species: 47%
May 23, 1986	April 7, 1986

*Scraper-grazer to detritivore ratio
**Amphipod to isopod ratio
***Percent of Total Individuals

Data were collected April-June 1986. For additional information refer to the article: Olive, John H., Jim L. Jackson, Joanne Bass, Lynda Holland, and Timothy Savisky. "Benthic Macroinvertebrates as Indexes of Water Quality in the Upper Cuyahoga River." *Ohio Journal of Science*. 88 (3): 91-98, 1988.

Use the following table to assess the water quality of each site. Add the scores (relative index values) for each category to obtain a composite score.

Composite Score: Site 1 ______ Site 2 ______

Answers

1a. Site 1 = 24, Site 2 = 8.

1b. Stillwell Road – 22; Infirmary Road – 13 The Stillwell Road site was similar to a riffle that may have intorduced a slight bias in the data. Infirmary Road was prone to inputs of organic material and had poor habitat for macroinvertebrates, thus factors other than water quality could affect the number of organisms observed. The station is 2 km below a wastewater treatment plant, yet the data do not necessarily suggest the effects of organic substances on the community of benthic organisms (Olive et al. 1988).

Table 7. Criteria based on benthic macroinvertebrate structure for establishing levels of water quality in the upper Cuyahoga River, Ohio.

	Relative index value				
Community structure characteristic	1	2	3	4	5
No. of species (or taxa)	0-10	11-20	21-30	31-40	>40
Density (no./m^2)	<500 or >400		500-1000 or 2000-4000		1000-2000
A/I*	<1-1		1-2		>2
S-G/D**	<0.2	.2-.4	.4-.6	.6-.8	>.8
Organic pollution intolerant***	<20	21-40	41-60	61-80	>80

*Amphipod to isopod ratio
**Scraper-grazer to detritivore ratio
***Percent of total organisms

Divide into teams, with each team selecting a different river that enters the Great Lake closest to your area. Work with your team to obtain water quality data from your river; for example, use the Internet or contact your local or state agencies for more information. Answer the same questions as with the Black and Cuyahoga Rivers: questions 1-5 and 9-11 of the Procedure section.

2. Discuss with your team what kind of water quality exists in the river you chose, and what might be the source of any water quality problems. Prepare a short presentation for the rest of the class to report this information.

3. Examine the data presented by other teams, so that you have information on several rivers entering your Great Lake. Based on what you have learned, are rivers contributing substantial water pollution to the Great Lakes? What are some specific problems or success stories you know about along these rivers?

If any of the classes' selected rivers enter the Great Lakes at a site designated as an Area of Concern, it would be valuable to follow this activity with the one titled, "What is the status of our Areas of Concern?"

REVIEW QUESTIONS

1. What data sources are available for learning about:
   a. Physical characteristics of a river and its watershed (topography, size, etc.)?
   b. Chemical characteristics of the water in a river?
   c. What kinds of living conditions are present in the river?
   d. What human developments exist in the watershed?

2. What other data sources would you like to have to give you more information about judging water quality?

3. Why is it important to learn about rivers in a study of the Great Lakes?

EXTENSION

Contact other schools along a river you have studied. Share water quality data and information from your classes' discussions. Organize a method of sharing river information with the community and its leaders. Use Great Lakes RAPs as a resource for how other communities organize around water quality initiatives.

REFERENCES

Fortner, R. W., Project Director; A. Lewandowski and Richard Meyer, Editors, 1996. *Great Lakes Solution Seeker* (CD-ROM). Columbus: Ohio Sea Grant Education Program, The Ohio State University.

GREEN – Global Rivers Environmental Education Network develops water education through water quality monitoring and examination of changes in watersheds. GREEN also provides information about education resources. Investigate the Internet site http://www.igc.apc.org/green/

Mitchell, Mark K., and William B. Stapp. 1992. *Field Manual for Water Quality Monitoring*. An Environmental Education Program for Schools. 6th ed. Dexter, MI: Thomas-Shore, Inc.

What happens when nutrients enter an estuary?

Along the shores of the Great Lakes are numerous marshes and estuaries. Many of them can be thought of as transition zones between a river and the Great Lake into which the river empties. These wetlands support a great diversity of plant and animal life. Abundant aquatic and terrestrial organisms use areas either on a temporary or permanent basis. Unique wetland habitats support a greater variety of plant and animal life than any other area of equal size in the region.

Estuaries are not easily defined. They have traditionally been characterized as the area where fresh water meets the sea and water levels rise and fall with the tides. Estuaries, however, can be more than just an aquatic interface between fresh and salt water. In a larger meaning, they are the part of the mouth of a stream in which the water level is influenced by the lake or sea into which the stream flows. In this case, they occur where rivers meet freshwater lakes. Many different habitats — marshlands, open water, sand beaches, upland forests, even cities and agricultural fields — can merge at these unique areas.

Terrestrial and aquatic vegetation serve several functions in an estuary. Emergent aquatic plants filter out large quantities of nitrogen, phosphorus, pesticides, and silt. Subsequently, some of the nutrients and toxins are taken up by the root systems of these aquatic plants. Without estuaries and marshes acting as a natural buffer zone, even greater quantities of pollution would enter the Great Lakes.

Additionally, plants provide a food source for herbivores and detritus feeders (organisms that feed on dead materials), which are the base of the lake food web. The thick layers of foliage in an estuary provide protective breeding and nursery grounds for fish and other aquatic animals. Finally, estuaries reduce the harmful flooding effects of storms in the Great Lakes watershed by absorbing large quantities of storm water and then slowly releasing the water into the lakes.

The following two activities demonstrate some of the beneficial environmental functions wetlands contribute to the ecosystem of the Great Lakes. Be sure to supplement these activities with (1) the estuary plankton and plant activities in the ES-EAGLS bundle, *Life in the Great Lakes*, and (2) a visit to the Internet site for the National Wetlands Inventory (www.nwi.fws.gov/data.html) to learn about the status of wetlands in your state.

How do phosphorus and nitrogen get into the Great Lakes? One way is from water runoff. Rainwater falling on farm fields, parking lots, roads, and backyards flows into creeks, streams, and rivers. The rainwater carries soil, fertilizers, and pollution it has washed from the land. You have probably seen how much more water creeks carry just after a storm and how muddy the water looks. Eventually, all this water runs into the lakes, bringing nutrients and other chemicals with it.

Sources

OEAGLS EP-29B, "Nutrients in the Great Lakes" by Chris Brothers, David A. Culver, and Rosanne Fortner.

Part K modified from Ecological Profile of Old Woman Creek Estuary (Task 3) and Nutrient Loading Model (Task 4) by Brian Luthy.

Earth Systems Understandings

These activities focus on ESU 2 (stewardship), 3 (science methods and technology), and 4 (interactions).

Materials

- Nitrate and phosphate data charts.
- Map of Old Woman Creek.
- Graph paper.
- Pencils.
- Glass jar with lid.
- Soil.

Answers

1. The creek flows north into Old Woman Estuary and then empties into Lake Erie.

2. U.S. Highway 6, Ohio Routes 2 and 61, and other roads run through the watershed. There are also several farms. Runoff water from roads and farms will carry pollutants and fertilizers. A land use map is included in ES-EAGLS *Life in the Great Lakes*.

3. There are seven water test stations in or near the estuary. Station 1 is closest to where the creek enters the estuary. Station 7 is near the entrance of the creek into Lake Erie.

OBJECTIVES

When you have completed this activity, you should be able to:

- List sources of nutrient inputs to Lake Erie.
- Explain how wetlands can improve water quality.
- Investigate the effects of nutrients on the microcopic species in an estuary.

PROCEDURE

A. Look at the map of Old Woman Creek on p. 151. With your pencil, trace the path of the creek, starting at the point marked **A**.

1. Where does the creek go? Does water from the creek flow into Lake Erie?

B. On the same map, look at the land that is surrounded by the dashed line. All the land within this line is the watershed of Old Woman Creek. Water from this land runs off into Old Woman Creek, then through Old Woman Creek Estuary, before reaching Lake Erie. A watershed is all of the land drained by a creek, stream, or river.

2. Are there any roads or farms in the Old Woman Creek watershed? How might these affect the water entering the creek?

C. The smaller inset map shows places in the estuary where scientists have tested the creek's water to see how much phosphorus and nitrogen it contains.

3. How many test stations are located in or near the estuary? Which station is closest to the lake? Which is closest to where the creek enters the estuary?

D. On a piece of graph paper, graph the concentration of phosphorus at Station 1 in the estuary for each day after the storm from day 1 to day 11. Use the data from the Nitrate and Phosphate Data Chart (See Figure 2).

4. At Station 1, how many days after the storm were phosphorus levels the highest? When were phosphorus levels the lowest? How can you explain this?

E. Now graph phosphorus concentrations at Stations 3 and 6 for each of the days after the storm. If you use the same sheet of graph paper to draw this graph, be sure to label your lines Station 1, Station 3, and Station 6.

5. What day did peak (highest) phosphorus concentrations occur at Station 3? What day did phosphorus peak at Station 6? Can you explain why peak concentrations of phosphorus occurred later at Station 3 than at Station 1 and later at Station 6 than at Station 3?

F. Look at the data showing nitrogen concentrations at Stations 1, 3, and 7.

6. On what day do the peak concentrations of nitrogen occur at each station? Does it seem that the peak nitrogen concentrations are following the same kind of pattern that peak phosphorus concentrations showed?

7. By day 9, have the peaks in phosphorus and nitrogen concentrations occurred at all seven stations?

G. On a new sheet of graph paper, make a graph of the concentration of phosphorus at each station in the estuary on day 9.

8. For day 9, at which station are phosphorus concentrations the highest? At which station are they the lowest? What might this suggest about the action of the estuary on water flowing through Old Woman Creek?

H. On the same graph paper you used in Step G, graph the concentration of nitrogen at each station in the estuary on day 9. (Note that N and P are not measured in the same units. This is consistent with the data.)

9. At which station are nitrogen concentrations the highest? At which station are they the lowest?

Answers

4. Phosphorus levels were highest 1 day after the storm and lowest 11 days after the storm's onset. At day 1, a lot of runoff water was entering the estuary. This water contained high concentrations of phosphorus. By day 11, there was much less runoff from the storm. Thus, fewer nutrients were being carried into the estuary.

5. Peak phosphorus concentrations occurred on day 3 at Station 3 and on day 4 at Station 6. Stations 3 and 6 are located further downstream in the creek. Water from the creek reaches Station 1 first, then Station 3, then Station 6. Nutrients such as phosphorus being carried by the water reach these stations in the same order.

6. Peak nitrogen concentrations occur at Station 1 on day 4, at Station 3 on day 6 and at Station 7 on day 8. Nitrogen concentrations are following the same general pattern as phosphorus concentrations. The peak concentration of nitrogen occurs at upstream stations before occurring downstream.

7. By day 9 the peaks in phosphorus and nitrogen concentrations have occurred at each of the stations.

8. Phosphorus concentrations on day 9 are highest at Station 1 and lowest at Station 7. This suggests that nutrients are removed as the water passes through the estuary before entering Lake Erie.

9. Nitrogen concentrations are the highest at Station 2 and the lowest at Station 7. Forms of nitrate and phosphate can be either dissolved in the water, suspended as particles, or attached to sediments.

Answers

10. Following a storm, creek water is muddy from carrying soil and nutrients, and it is moving very quickly. As water flows through the estuary, its movement is slowed. Much of the sediment, soil, and nutrients in the water settles out as the water slows down. Thus, the water reaching downstream stations is clearer and has lower concentrations of nutrients than the water flowing through the upstream stations.

11. To explain the decrease in the phosphorus and nitrogen concentrations from Station 1 to Station 7, try the following: Plants in the estuary need phosphorus and nitrogen as nutrients to grow. Thus, plants in the estuary take up and use phosphorus and nitrogen from the creek water as it passes through the estuary. The plants filter out nutrients that they need from the creek water. This is another reason why fewer nutrients reach the downstream stations.

12. Because of the estuary's filtering action, water entering the lake will contain fewer nutrients than it otherwise would. Many of Lake Erie's water problems result from too many nutrients entering the lake. Estuaries may improve water quality in the lake by reducing the nutrients entering it.

13. The numbers of many species have either increased or decreased, probably due to the fertlizer in the runoff. Overall abundance has increased, algae have a huge increase, carnivores have a large decrease.

I. Fill a jar half full of water. Put a handful of soil into the jar. Shake the jar so that the water and soil are moving quickly and get mixed together. You have created muddy, stirred–up creek water in your jar. Wait a few minutes for the water to slow down and the soil to settle to the bottom of the jar. The water in the jar now is more like water in the estuary.

  10. Where do you think estuary water will be the muddiest? Where will it be the clearest? What is one reason why phosphorus and nitrogen concentrations are lower at Station 7 than at Station 1?

  11. The estuary has many plants growing in it. How might the plants affect the amount of nutrients reaching each station?

J. Estuaries and other wetlands act as sinks and sponges of nutrients. Nutrients associated with mud settle out of the creek water and sink to the bottom of the estuary as the water passes through the estuary. At the same time, nutrients are taken up by estuary plants for growth.

  12. How might an estuary's action as a sink and sponge for nutrients affect the lake into which the creek empties?

K. You decide to learn more about the effect of nutrient loadings on the biology of the estuary by taking a plankton sample 4 days after the storm. You want to compare your sample to another student's sample collected prior to the runoff entering the estuary. After crossing the railroad line you select a site for your sample, halfway between station 1, 2, and 4. You collect a 1.00 liter sample of surface water assuming that most plankton live in the upper 3 feet of water, and that this level represents an average water volume of 100,000 liters throughout the estuary. To examine the sample, you place a drop on a slide, remembering that there are 2,000 drops in a liter. Numbers from your sample must be multiplied by 2,000 and then by 100,000 to obtain an estimate of the total population for each species. Use the multiplication factor to complete the data chart in Figure 3, i.e., population size after storm and change in population size.

  13. How did the storm runoff affect the ecology of the estuary? How has the overall abundance of species changed? Which species have increased? Which species have decreased?

14. Which species may become overpopulated after the storm?

15. How will an overpopulation of these species affect the other species?

16. If there were toxins in the runoff, instead of fertilizer nutrients, which species would be in the greatest danger?

17. What efforts might reduce runoff and the amount of nutrients entering the estuary?

EXTENSION

1. *How does stratification affect water quality?* Great Lakes Climate and Water Movement, Activity Set from Earth Systems/Ohio Sea Grant Education Program, The Ohio State University. It includes two activities related to nutrients in the lakes and water quality. Students simulate the stratification of water that occurs in lakes during the summer using an aquarium. On several maps of Lake Erie, they measure the lake area that has become anoxic (lacking oxygen) since the 1930s and relate this to nutrient inputs.

2. How do the characteristics of oligotrophic and eutrophic lakes differ in terms of nutrients? How would biological diversity differ between the two kinds of lakes? Do research to determine how you would classify each of the Great Lakes according to trophic status.

3. *What is the role of plants in an estuary?* and *How does the estuary serve as a nursery?* Life in the Great Lakes, Activity Set from Earth Systems Education Program, The Ohio State University. Students study sampling techniques in an estuary including a transect line for macro-organisms and a random sampling method for micro-organisms.

REVIEW QUESTIONS

1. How do estuaries act as "sinks" and "sponges" to improve the quality of water going through them and reaching the lake?
2. Analyze the possible impact of increased nutrients on the microorganisms present in the wetland. Discuss how the increase of nutrients may be beneficial or detrimental to the wetland.

Answers

14. Many of the algae species may become overpopulated after the storm.

15. Too many algae will cause the estuary to become eutrophic, using up lots of oxygen to decompose the bodies of the dead algae as they fall to the bottom. This will affect consumers who utilize oxygen.

16. The top carnivores would be in the greatest danger of toxin poisoning; they would accumulate a little bit of the poison from each of the prey they ate, and the toxin would accumulate in their bodies, called biomagnification.

17. Try to find alternative ways to fertilize fields, find ways to reduce runoff and erosion, find ways to intervene when fertlizers do accumulate in waters and stimulate algae growth.

Hint for Extension

2. Oligotrophic lakes have low nutrient levels. They are often deep and have small surface areas. Plant production is low, and the water is clear. Eutrophic lakes are rich in nutrients. They are often shallow and have large surface areas. Plant production is high, and the water is murky. Lakes may also be classed as mesotrophic, with characteristics between the other two types.

REFERENCES

Herdendorf, Charles E. 1993. Recovering from phosphorus enrichment. In, Rosanne W. Fortner and Victor J. Mayer (eds.), *The Great Lake Erie*. Ohio Sea Grant. p. 136.

Klarer, D. 1988. "The role of a freshwater estuary in mitigating storm water inflow." OWC Technical Report #5. Huron, OH: ODNR Division of Natural Areas and Preserves.

Leary, Nelson H. 1985. Those summertime blue-greens. *The Conservationist*. July/August, p. 9.

Reutter, Jeffrey M., Frank R. Lichtkoppler and Charles E. Herdendorf. "Lake Erie: Phosphorus and Eutrophication." Ohio Sea Grant Fact Sheet #15.

Vallentyne, John R. 1974. "The Algal Bowl: Lakes and Man." Ottawa, Canada: Dept. of the Environment Fisheries and Marine Service.

Figure 1. The Old Woman Creek Watershed with Water Test Stations.

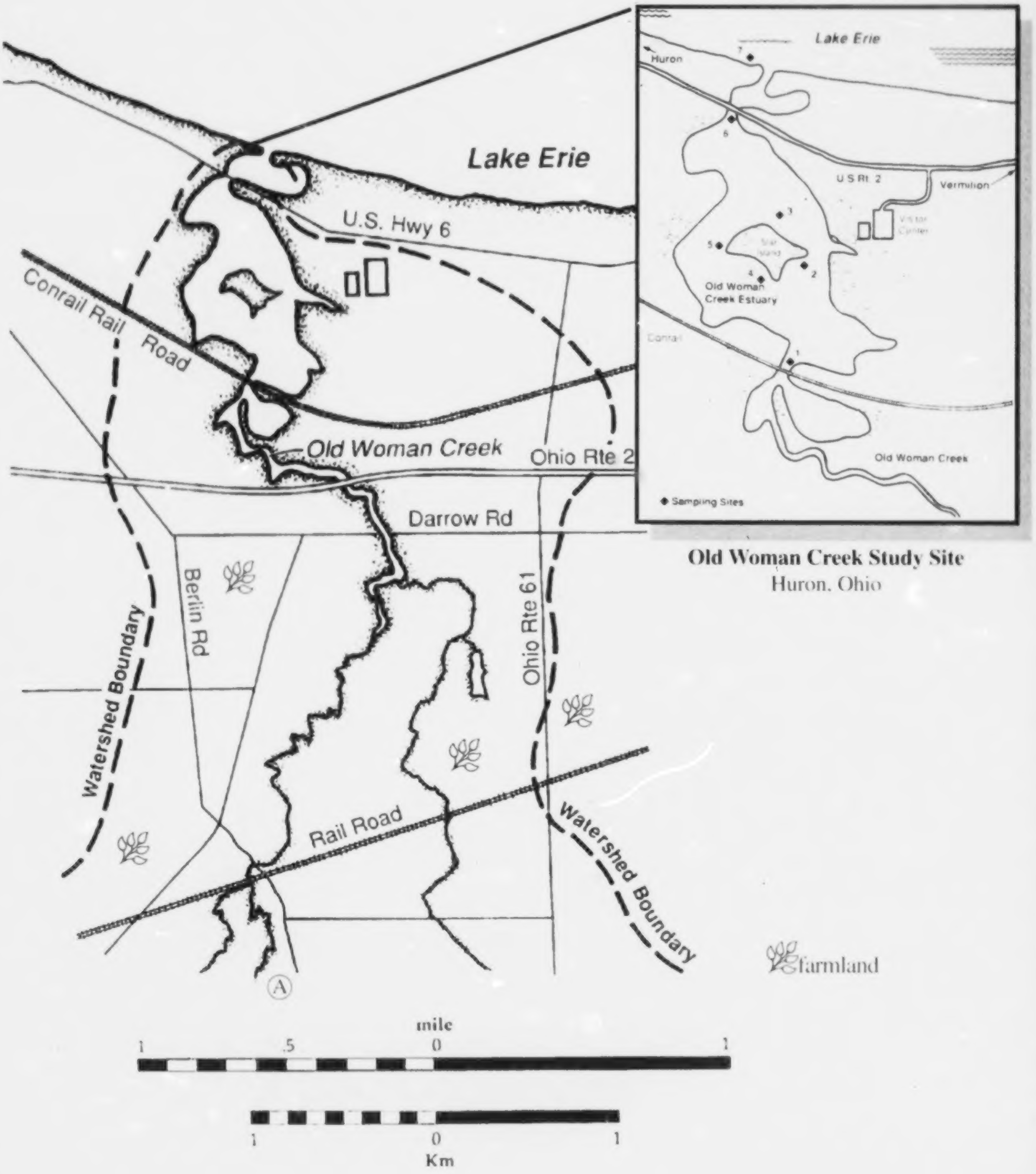

Lake Erie
U.S. Hwy 6
Conrail Rail Road
Old Woman Creek
Ohio Rte 2
Darrow Rd
Berlin Rd
Ohio Rte 61
Watershed Boundary
Rail Road
Watershed Boundary
A
Lake Erie
Huron
7
6
U S Rt 2
Vermilion
3
5
4
2
Visitor Center
Old Woman Creek Estuary
Conrail
1
Old Woman Creek
◆ Sampling Sites
Old Woman Creek Study Site
Huron, Ohio
farmland
mile
1
.5
0
1
1
0
1
Km

Figure 2. Changes in nitrate and phosphate concentration in water at sites along Old Woman Creek for a period following a storm.

Day After Storm (May 1985)

Station	Nutrient	1	2	3	4	5	6	7	8	9	10	11
1	P (ppb)	283	82	70	94	60	32	40	49	40	35	30
	N (ppm)	6.5	6.9	9.7	12.4	10.5	9.5	7.8	6.5	6.6	6.5	6.6
2	P	104	97	79	79	50	35	21	12	10	7	3
	N	1.5	3.3	6.1	8.7	9.0	10.1	9.0	8.0	7.7	6.5	5.9
3	P	9	41	67	66	32	19	15	10	9	8	7
	N	.4	1.9	2.8	7.6	5.4	9.9	8.0	6.8	5.8	4.1	2.3
4	P	9	7	35	28	29	11	11	10	7	5	3
	N	.2	.3	2.4	3.3	5.1	8.8	8.7	8.4	6.5	4.8	2.2
5	P	8	11	10	22	20	16	12	10	6	3	2
	N	.2	.8	.6	2.6	4.9	9.7	7.8	6.9	6.0	4.1	2.3
6	P	9	5	10	26	19	11	10	10	8	6	5
	N	.5	.5	2.0	3.4	3.4	3.4	3.3	3.3	3.0	2.7	1.7
7	P	5	2	4	6	5	3	3	3	2	2	2
	N	.9	1.0	1.1	1.4	1.6	1.7	2.0	2.1	1.7	1.5	1.2

(Data for underlined dates were interpolated from those before and after the date. P and N were not measured directly on these days.)

Figure 3. Planktonic organisms collected in an estuary before and after a storm.

	Species Name	Original Number Sampled	Multiplication Factor	Estimated Total Population Pre-storm	Number Sampled After Storm	Estimated Total Population Post-storm	Change in Total Population Size
1.	M. aureus	1	x 2,000,000	2000000	2		
2.	Sarcina lutea	2	x 2,000,000	4000000	1		
3.	Bacillus subtilis	4	x 2,000,000	8000000	3		
4.	water mold	4	x 2,000,000	8000000	2		
5.	R. nigricans	4	x 2,000,000	8000000	3		
6.	slime mold	2	x 2,000,000	4000000	3		
7.	microcystis	7	x 2,000,000	14000000	11		
8.	anabaena	6	x 2,000,000	12000000	16		
9.	rivularia	9	x 2,000,000	18000000	24		
10.	nodularia	6	x 2,000,000	12000000	39		
11.	spirogyra	4	x 2,000,000	8000000	17		
12.	cladophora	4	x 2,000,000	8000000	5		
13.	ulothrix	8	x 2,000,000	16000000	20		
14.	cyclops	4	x 2,000,000	8000000	2		
15.	daphnia	4	x 2,000,000	8000000	3		
16.	amoeba	1	x 2,000,000	2000000	1		
17.	paramecium	3	x 2,000,000	6000000	2		
18.	stentor	3	x 2,000,000	6000000	2		
19.	yellow perch	4	x 2,000,000	8000000	0		
20.	gizzard shad	2	x 2,000,000	4000000	1		
21.	emerald shiner	6	x 2,000,000	12000000	0		

Answers

	Estimated Total Population Post-storm	Change in Population Size
1.	4000000	2000000
2.	2000000	-2000000
3.	6000000	-2000000
4.	4000000	-4000000
5.	6000000	-2000000
6.	6000000	2000000
7.	22000000	8000000
8.	32000000	20000000
9.	48000000	30000000
10.	78000000	66000000
11.	34000000	26000000
12.	10000000	2000000
13.	40000000	24000000
14.	4000000	4000000
15.	6000000	2000000
16.	2000000	2000000
17.	4000000	-2000000
18.	4000000	-2000000
19.	0	-8000000
20.	2000000	-2000000
21.	0	-12000000

Students may wish to learn more about the plankton organisms using field guides to pond life. The fish listed (19-21) are larval forms whose adult stages can be studied with guides to freshwater fish.

What is the status of the Great Lakes Areas of Concern?

The International Joint Commission (IJC) the organization formed in 1909 by Canada and the United States to assist in resolving transboundary water resource issues, including water quality, water quantity, and water resource use. It has identified 43 Areas of Concern (AOC) in the Great Lakes basin in which the aquatic conditions are considered to be the most severely degraded. Twelve of these AOCs are entirely within Canada, 26 are entirely with the U.S. and the rest are on boundary rivers shared by both countries.

In 1987, the two nations revised the Agreement and committed themselves to develop and implement Remedial Action Plans (RAPs) for the AOC. RAPs identify specific problems in the AOC and prescribe methods for correcting them.

On the Canadian side, the Ontario Ministry of Environment and Energy (MOEE) and Environment Canada are the lead agencies in developing RAPs. On the U.S. side, state and federal agencies cooperate. Possible funding is generated from federal water quality programs authorized by the Clean Water Act including: state sewage treatment construction grants and state enforcement grants from the USEPA, nonpoint source pollution control grants, The Great Lakes National Program Office (GLNPO) grants for RAP projects, water quality management planning grants, and research grants awarded by the USEPA. Additional sources include: The Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), as 16 AOC sites qualify under Superfund, USDA Agricultural Stabilization and Conservation Service through cost sharing, the 1990 U.S. Farm Bill and its Water Quality Incentive Program, the Water Resources Development Act authorizing technical and engineering expertise by the US Army Corps of Engineers for RAPs, Section 306 grants of the Coastal Zone Management Act (CZMA), and state funds such as general revenues, fees and taxes. Public involvement varies by state and AOC site. Many citizen groups, private interests, and public agencies may contribute to clean up efforts through RAP programs.

This activity is a starting place for an investigation of Great Lakes issues as they are exemplified in the AOCs. More importantly, a review of the RAP process demonstrates how individuals and organizations have become actively involved in restoring environmental quality to degraded sections of the Great Lakes.

The activity is most easily done using Internet resources or the 1996 CD-ROM from the Ohio Sea Grant Education Program. When the CD is run on Macintosh, a Hypercard stack is available to answer the questions and to allow exploration of remote images of the areas. On Windows platforms, individual files will open if Netscape 2.0 or higher is resident on the machine. The CD will also access the Internet if the computer is online.

OBJECTIVES

When you are finished with this activity you should:

- Understand how and where to find information concerning environmental "hot spots" in the Great Lakes.
- Describe the environmental degradation that has occurred in an Area of Concern near you and what is being done to correct the situation.

Earth System Understandings

This activity focuses on Earth System Understandings 1 (beauty and value), 2 (stewardship), 3 (science process) and 7 (careers and hobbies).

Materials

- Online computer access (optional).
- Great Lakes reference materials.
- Great Lakes Solution Seeker CD, if possible.

Teacher's Note

The students can be divided into groups to investigate different AOCs and then make presentations concerning their specific area, or the entire class can study the same area and create a display.

Students can discuss how the degree of public involvement varies by AOC location and RAP process, and how a site can eventually be delisted from among the AOCs.

Some students may want to investigate possible jurisdictions for RAP programs (laws, agreements, offices): Great Lakes Water Quality Agreement, Clean Water Act, Great Lakes National Program Office (GLNPO), Great Lakes Critical Programs Act (1990), Pollution Prevention Act of 1990, Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), Resource Conservation and Recovery Act (RCRA), Clean Air Act, U.S. Army Corps of Engineers, specifically dredging issues, 1990 Farm Bill, etc.

PROCEDURE

1. Select an Area of Concern (see the included list) and do research on the environmental problems of that area. You may use the included list of resources as a starting place for your research. When you are finished investigating your area you should be able to answer the following questions about it:

   a. What pollutants are impacting the area? At what concentration are the pollutants dangerous?
   b. Where do these pollutants come from?
   c. What effect are the pollutants having on plant, animal and human life?
   d. What specific human activities (industry, shipping, recreation) would have to change in order to prevent futher pollution of the area? How might this change the economy?
   e. What is being done about the problems, i.e., what Remedial Action Plans (RAPs) are in place?
   f. What groups are working on the solution to the pollution problems? Are schools and students involved in any way?
   g. What factors should be considered in the design of a feasible solution? (Are there economic effects, health and safety issues?)
   h. What do you think is a feasible solution the problem?

2. Decide how to make a creative presentation of the information you gather, so the rest of your class and/or to your school will learn of your findings.

We recommend using the CD-ROM: *Great Lakes Soulution Seeker* from Ohio Sea Grant as a summary of the areas of concern. If run on Macintosh, a Hypercard stack provides an excellent overview, investigation questions, and software tools for learning more about the areas.

FORTY-THREE AREAS OF CONCERN

CANADA

Lake Superior

1. Thunder Bay
2. Nipigon Bay
3. Jackfish Bay
4. Peninsula Harbour

Lake Huron

5. Collingwood Harbour*
6. Severn Sound
7. Spanish River

Lake Erie

8. Wheatley Harbour

Lake Ontario

9. Bay of Quinte
10. Port Hope Harbour
11. Metro Toronto
12. Hamilton Harbour

U.S.A.

Lake Superior

13. St. Louis Bay
14. Torch Lake
15. Deer Lake

Lake Michigan

16. Manistique River
17. Menominee River
18. Fox River
19. Sheboygan River
20. Milwaukee Estuary
21. Waukegan Harbor
22. Calumet River
23. Kalamazoo River
24. Muskegon Lake
25. White Lake

Lake Huron

26. Saginaw River

Lake Erie

27. Clinton River
28. Rouge River
29. River Raisin
30. Maumee River
31. Black River
32. Cuyahoga River
33. Ashtabula River
34. Presque Isle Bay
35. Buffalo River

Lake Ontario

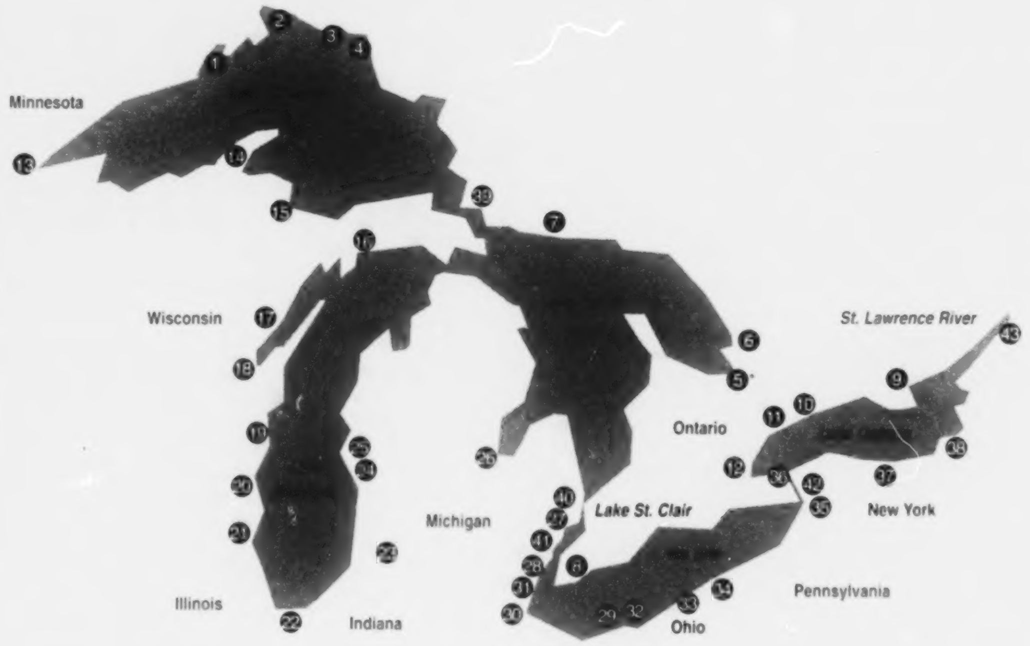
36. Eighteenmile Creek
37. Rochester Embayment
38. Oswego River

CONNECTING CHANNELS

39. St. Marys River
40. St. Clair River
41. Detroit River
42. Niagara River (Ontario)
    Niagara River (New York)
43. St. Lawrence River (Cornwall)
    St. Lawrence River (Massena)

* Site delisted as of this printing

IJC 43 Areas of Concern


Minnesota
Wisconsin
Illinois
Indiana
Michigan
Lake St. Clair
Ontario
Ohio
Pennsylvania
New York
St. Lawrence River
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4
5
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* This AOC (5) has restored its beneficial uses and is no longer considered to be an Area of Concern.

RESOURCES

For information on RAPs in Canada, contact the Ontario Ministry of Environment & Energy (MOEE) or Environment Canada:

MOEE
Public Information Centre
135 St. Clair Avenue West
Toronto, Ontario M4V 1P5
5Y4

Environment Canada
RAP Involvement Coordinator
4905 Dufferin Street
Downsview, Ontario M3H

(416) 739-5835

Glassner, Kathe, Noah Eiger, Daniel Ray, and Paul Botts. 1991. *Making RAPs Happen. Financing and Managing Cleanups at Great Lakes Areas of Concern.* 1991. The Center for the Great Lakes. Order AOC fact sheets from: The Center for the Great Lakes Information Service

General Information on AOCs, RAPs and Lakewide Management Plans(LaMPs)
Water Quality - Areas of Concern
http://www.cciw.ca/glimr/gl-programs/RAPs/intro.html

Great Lakes RAPs:
http://www.great-lakes.net/envt/water/rap.html

Lakewide Management Plans (LaMPs):
http://www.great-lakes.net/envt/water/lamp.html

Great Lakes Regional Partners
International Joint Comission (IJC)
http://www.ijc.org

Great Lakes Commission: http://www.glc.org/

*Council of Great Lakes Governors:*http://www.great-lakes.net/partners/cglg/

Canadian Links
Great Lakes Programs Canada
http://www.cciw.ca/glimr/gl-programs/intro.html

Environment Canada - Sites
http://www.on.doe.ca/@html/ecsites.html

United States Information Sources

Sea Grant Great Lakes Network:
http://www.seagrant.wisc.edu/greatlakes/glnetwork/glnetwork.html

National Oceanic and Atmospheric Administration (NOAA)
Great Lakes Environmental Research Lab:
http://www.glerl.noaa.gov/

Contaminants and the Great Lakes:
http://h2o.seagrant.wisc.edu/greatlakes/glnetwork/toxics.html

Health effects of toxins
http://atsdr1.cdc.gov:8080/

United States Geological Survey (USGS) in the Great Lakes:
http://water.usgs.gov:80/public/wid/html/gl.html

U.S. Environmental Protection Agency (EPA) Great Lakes National Program Office:
http://glnpogis2.r05.epa.gov/glnpo/glnpo.html

Great Lakes Protection Fund:
http://www.great-lakes.net:2200/partners/GLPF/glpf.html

Where does oil pollution come from?

When oil is poured on rough waters, the surface of the water is calmed. In ancient Greece, sponge divers made use of this fact and carried oil in their mouths when they began a dive. Releasing the oil smoothed the ripples and gave them better light for searching below. Today, mariners will sometimes dump oil to calm ocean waves and make rescue easier.

Oil on water is not always welcome, however. Accidents in which oil is spilled in the water definitely do not have a calming effect on people. Our recent history records a distressing number of tanker spills, offshore drilling accidents, and mysterious oil slicks of unknown origin.

The U.S. National Academy of Sciences estimated in 1975 that 6,100,000 metric tons of petroleum products enter the world's oceans each year. (This is usually written as 6.1 mta. A metric ton is 1 million grams, or 1.1 regular tons.) About 2.3 percent of this total, or 0.14 mta, originated from oil spills in the Great Lakes. The total amount of petroleum products was calculated as 3.2 mta for a 1985 study; thus, the figures have changed. The petroleum pollution comes from many sources, some natural and some from human activities. In the Great Lakes, in 1974, for example, an oil spill from the tanker *Imperial Sarnia* caused damages to the St. Lawrence Seaway that cost about $2,000,000 to clean up. In 1961 another tanker spill on the St. Lawrence River was reported to have caused the extinction of the last colony of Greater Snow Geese. Search the Internet to learn about oil spills, such as the recent Exxon *Valdez*. Investigate the Great Lakes information network regarding contingency plans in the region – http://www.great-lakes.net/pollution/emerg.html. Also explore U.S.E.P.A.'s oil spill program and the Great Lakes Commission's related Web sites.

2-16
Dunagin

"NO, I HAVEN'T HEARD ABOUT THE OIL SHORTAGE — TELL ME ABOUT IT!"

DUNAGIN's PEOPLE by Ralph Dunagin © 1973 Field Enterprises, Inc. Courtesy of Field Newspaper Syndicate

Materials

- Protractor
- Pencil
- Circle in Figure 1

Earth System Understanding

This activity encourages students to consider ESU 2 (stewardship) in identifying sources of oil pollution and 3 (scientific thinking and technology) by using math skills to consruct graphs.

Source

Modified from OEAGLS EP-12 *Oil Spill*, Activity A by Stephanie Ihle and Rosanne W. Fortner.

Teacher's Note

Review questions for all oil spill investigations are at the end of the third activity.

OBJECTIVES

When you have completed this investigation, you should be able to describe the major sources of oil pollution in the oceans and Great Lakes.

PROCEDURE

In this activity you will construct a "pie" graph showing what part of the total petroleum pollution in the oceans comes from different sources. The list on the next page tells how many million metric tons annually (mta) come from different sources, according to the two studies noted. It also tells what percent of the total petroleum pollution this is.

The whole circle in Figure 1 represents the 6.1 mta discussed for the 1975 data. You will divide the circle into wedges that look like pieces of pie. The size of each wedge will depend on the amount of petroleum from one source.

To find how big a wedge to draw for each pollution source, you will have to do an arithmetric problem.

A. A circle can be divided into 360 equal parts called degrees. Multiply the percent (column 2) by 360, and write your answer in column 3. If one pollution source is responsible for 10 percent of the total oil pollution, you would multiply 0.10 (same as 10 percent) x 360 degrees. Your answer is 36 degrees.

B. Do all your work on your own paper. Place your protractor on a line running from the center of the circle to its outer edge. The point at the center of the protractor base should be on the center of the circle.

C. Reading from the bottom line of the protractor around the arc, find the point that represents your answer from column 3. Place a dot on the circle at that point.

D. Draw a line from the center of the circle to the edge of the circle through your dot. Label the wedge as shown in the example in Figure 1.

E. Complete the chart on your worksheet, and check your work by adding up the numbers in column 3. The total should be 360 degrees by rounding your answers to the nearest degree.

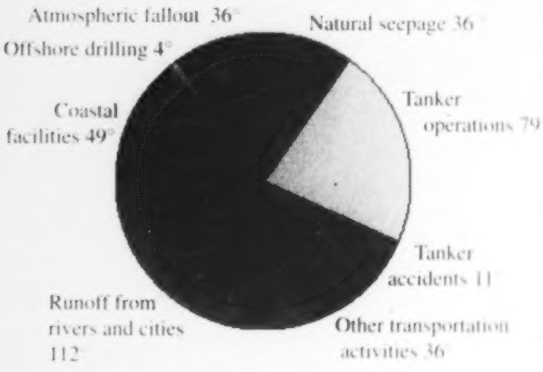
F. Divide your pie graph into wedges as the example shows. Since the graph represents the total amount of oil pollution in the oceans, the entire circle will be filled with wedges when you finish.

G. Repeat the same procedure for the 1985 data. Compare the pie graphs. How have the data changed?

Teacher's Notes

Any spreadsheet / graphing program for microcomputers can accomplish this task. Instructions given are for manual graphing.

Completed graphs should have the sections shown below. The number of degrees in each wedge should match those calculated in the student charts for this activity. We have rounded to the nearest whole degree. The arrangement of the wedges within the circle may differ because of students using different wedge sides as base lines.



Sources of Petroleum in the Marine Environment

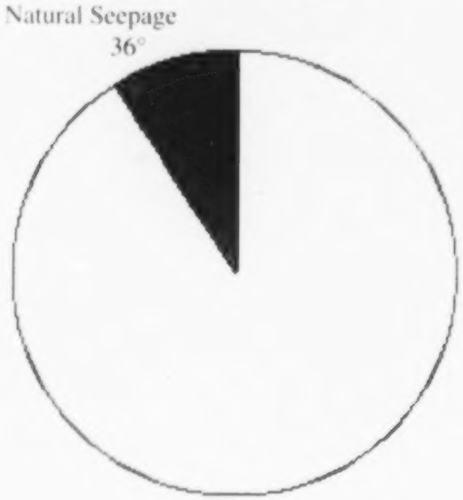
Source of Petroleum	1975 mta	% of total	Size of Wedge	1985 mta	% of total	Size of Wedge
Natural seepage*	0.60	10	36°	0.25		
Tanker operations	1.33	22		0.7		
Tanker accidents	.20	3		0.4		
Other transportation activities	0.60	10		0.4		
Runoff from rivers and cities	1.90	31		1.1**		
Coastal facilities	0.80	13				
Offshore drilling	0.08	1		0.05		
Atmospheric fallout	0.60	10		0.3		
Total	6.11	100%	360°	3.2	100%	360°

* Natural seepage: Leaks from oil deposits. In the Great Lakes, for example, oil seeps into the water from deposits at Oil Springs, Ontario.

** Definitions of the data were revised so that 1.1 represents the total for Municipal and Industrial Wastewater Discharges and Runoffs (1.0) and Refinery Wastewater Discharges (0.1). Runoff from rivers and cities, and Coastal facilities are included as categories for the 1985 data.

(Data from 1975 and 1985 studies in *Fate and Effects of Oil in the Sea*. Exxon Corporation, 1985.)

Figure 1. Oil Pollution Sources.



The location of oil spills changes dramatically from year to year. The graph here shows 1984 spill areas.

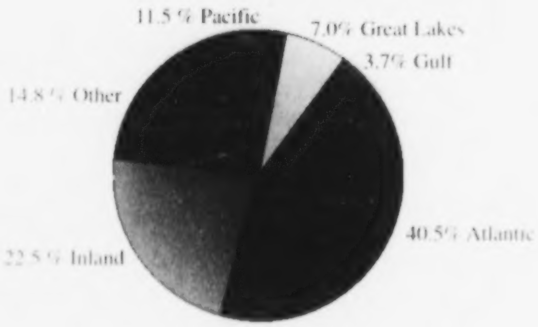


Figure 2. Oil Pollution Incidents by Area, 1984. U. S. Coast Guard, Polluting Incidents In and Around U.S. Waters. COMDTINST M16450.2G, 1987.

Now look at Figure 2. In this second pie graph you can see how the oil pollution was distributed in the waters of the U.S. in 1984. Notice that the wedge for the Great Lakes is about 1/5 the size of the one for the Atlantic Coast. The area of the Atlantic Ocean is about 115 times the area of the Great Lakes. The damage done by the oil pollution in the Lakes is much more concentrated and therefore does more visible damage than Atlantic oil pollution.

Answers

1. Tanker accidents are the most publicized source of oil pollution. Discuss with students some possible reasons why we hear more about these than about municipal oil pollution, coastal facilities as polluters, etc.

ANALYZING THE DATA

1. Most of the oil spills we hear about involve which one of the wedges in Figure 1?
2. Compare this source to other sources of petroleum pollution. Are there sources of oil pollution that do not make the news very often?

Reprinted by permission from Alchemy mindworks.

Occasional massive spills such as the Exxon *Valdez* are almost certainly less damaging to the marine environment than frequent smaller releases of oil in a confined harbor. (Notice the size of the "Coastal Facilities" wedge.)

When an oil tanker (ship) is carrying no oil, it fills up its cargo space with water so the ship will be stable. A substance used for stability this way is called **ballast.** Ships getting ready to load on a new cargo used to dump the water they were using as ballast. This ballast had picked up oil from the hold, and the oily wastes were flushed out into the harbor.

Today, regulations prohibit the dumping of oily ballast, and haulers reclaim much of the oil that had been lost this way.

3. Which of the wedges describes this type of pollution source?

4. How could oil get into the water from offshore drilling operations?

You may wish to read about the Ixtoc oil spill in 1979 in the Gulf of Mexico. (See *Newsweek Magazine* issues for August 13, 1979, and August 4, 1980.) The International Joint Commission (a cooperative agency of the U.S. and Canada) has prohibited drilling for oil in Lake Erie because of the risks of such a disaster. Canada drills for natural gas in the lake, but the U.S. does not. The environmental impact of drilling is now under consideration.

5. From Figure 2, what body of water gets the greatest volume of oil pollution? What kinds of areas are these?

6. List some ways that petroleum could get into rivers. (Hint: Refer to Figure 1 for some ideas.)

The next time you are riding along the highway, look at the road ahead of you. A well-traveled highway usually has a dark streak running down the center of each lane. The streak is caused by petroleum products such as crank case oil that drips out of vehicles.

3. Tanker operations. Much of the tanker industry now avoids the oily ballast problem by using the "Load-on-Top" (LOT) technique. During tank cleaning, dirty water is pumped into holding tanks where the oil separates and rises to the surface. Water from under the oil is pumped out and the remaining contaminated mixture stays in the ship while new cargo is loaded in on top.

4. Oil could escape from offshore drill rigs by breaks in pipelines, "blowouts" from gas in the wells, storm damage to the rigs' stability, or faulty equipment. An offshore drill rig is extremely expensive, however, and pressure for environmental protection is strong. Oil companies have devised numerous safeguards and maintain close observations of weather, equipment and personnel to prevent problems that would result in a spill. The American Petroleum Institute states that the chances of an oil spill from an offshore rig are 5000 to 1.

Students may think of other ways oil could escape. Have students investigate such problems by searching for educational information available from the American Petroleum Institute, 1220 L Street, NW, Washington, DC 20005.
Contact the American Petroleum Institute online: http://www.api.org

5. The Atlantic Ocean gets the most oil pollution.

6. Petroleum could get into rivers from oil dumped on land, oil dumped into streams, truck, rail or barge accidents, structural failure of pipelines, local spills at service stations, etc. Discuss a wide range of student ideas. Known sources of oil pollution are shown here.

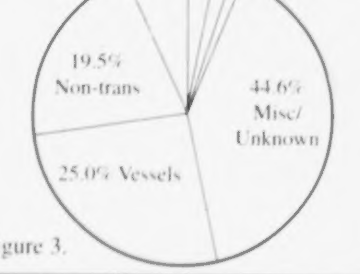


Figure 3.

Answers

7. The "highway streak" could be washed into waterways by rain, snow removal, or street cleaning operations.

8. Answers will vary widely. Accept and discuss all possibilities. Some choices might include disposing of waste motor oil properly, keeping cars maintained so they do not drip oil, not letting gasoline overflow from the gas pump, using fewer petroleum products so the United States does not have to import or drill for so much

Additional sources of information

Exxon Corporation "Natural Recovery through Bioremediation" 1991. Videotape on use of petrophilic bacteria to clean up the Valdez oil.

Exxon Corporation, 1985. *Fates and Effects of Oil in the Sea*. Exxon Background Series.

The Exxon Company created a 22-minute film on the spill of the *Valdez*. The film is called "Scientists and the Alaska Oil Spill: the Wildlife, the cleanup, the outlook" 1992. It is available free.

Alaska's Oil Spill Public Information Center gave permission to use the photo here. Others are available at the Web address (www.alaska.net/~ospic)

Alaska Sea Grant has an oil spill curriculum for all grade levels based on the Valdez spill.

7. How could this serve as a source of oil pollution for water?

8. What could your family do if you wanted to reduce the amount of petroleum products going into our water?

EXTENSION

Conduct research to determine where the majority of oil pollution comes from in your local community and which waters it pollutes. Find out if oil levels in water are measured in your immediate area.

Cleaning up an oil-soaked beach.

How can an oil spill be cleaned up?

The moment a spill occurs, nature begins cleaning up. The oil separates into heavier and lighter parts and is spread by wind and currents. Some of it evaporates, like gasoline spilled from the gas pump. Certain types of bacteria called petrophiles consume some of the oil. According to marine affairs specialist E. W. Seabrook Hull, "Within a couple of years no sign of the disaster remains. The oil is gone, and the birds and other marine life are back, as though nothing had happened. This has been shown in the case of *Torrey Canyon*, the *Wafra*, the *Arrow*, the *Argo Merchant*, Santa Barbara and numerous other events."

Success in cleaning up an oil spill depends upon preparedness and rapid action by the spiller and by Federal, state, and local agencies. When a spill occurs, in U.S. waters it is reported to the nearest U.S. Coast Guard station. The spiller, by law, is supposed to clean up the oil. If the spiller does not clean up the pollution, the Coast Guard takes over, and the spiller pays the clean-up costs. In this activity your team will create an oil spill and try various methods of cleaning it up.

OBJECTIVES

When you have completed this investigation, you should be able to compare the effectiveness and impact of three ways in which oil may be removed from water.

Materials:

For each team of students:
- Paper bowl or butter tub.
- Water.
- 10 ml of motor oil.
- 25-cm pieces of twine.
- Handful of straw.
- Handful of sand.
- Newspapers to cover working surfaces.
- Matches.
- Wooden splints.
- Paper towels.
- Liquid detergent.
- Dropper.
- Safety glasses.
- Alcohol burner.

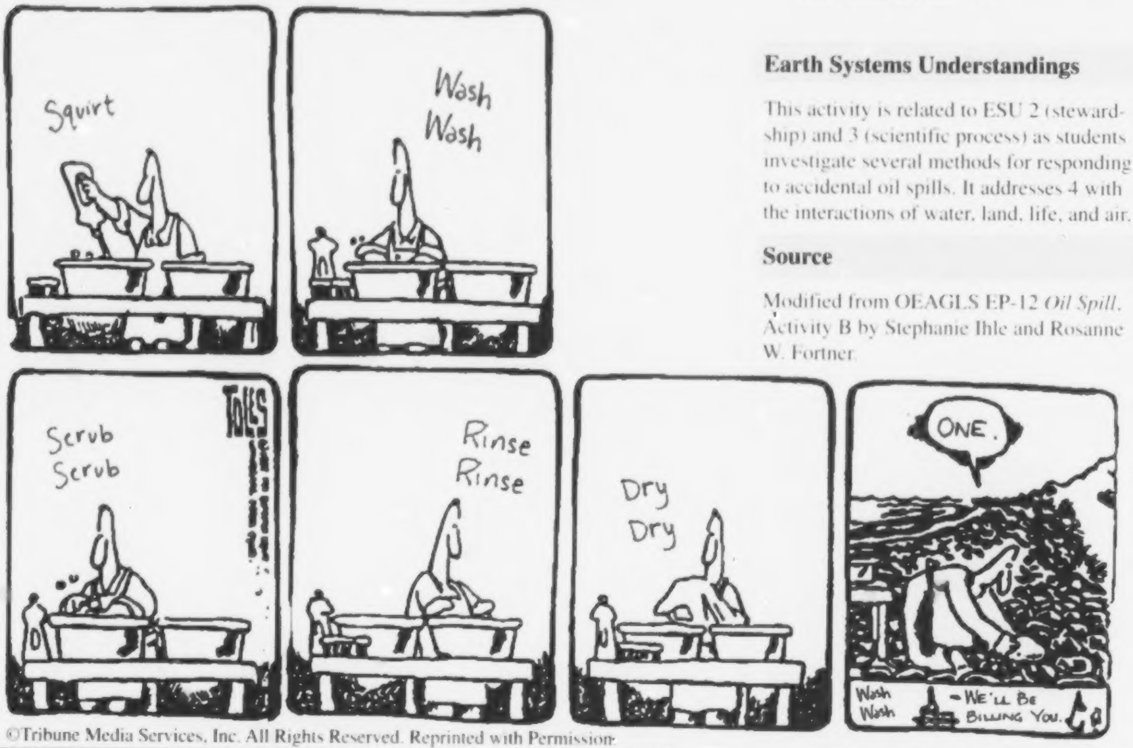
Earth Systems Understandings

This activity is related to ESU 2 (stewardship) and 3 (scientific process) as students investigate several methods for responding to accidental oil spills. It addresses 4 with the interactions of water, land, life, and air.

Source

Modified from OEAGLS EP-12 *Oil Spill*, Activity B by Stephanie Ihle and Rosanne W. Fortner.

Eugene, Oregon, Sunday, April 16, 1989



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PROCEDURE

I. CONTAINMENT

If an oil spill is quickly contained in one area, cleanup is easier, and less environmental damage is likely to occur.

1. Add about 2 cm of water to your butter tub or bowl to serve as a lake. An oil tanker has sprung a leak in the middle of your "lake." Add two drops of oil to the water's surface.
2. Tie the ends of a piece of string together and gently place the circle of string on top of the water, with the oil inside. Slowly add 2 ml more oil inside the circle. Pull the oil to one side of the pan using the string.
3. Does the string keep the oil from spreading over the entire lake? This is how a "boom" operates to contain a spill.
4. Some contained oil can be reclaimed (collected for further use). Use a dropper to try to reclaim some of your oil. About how much oil were you able to reclaim?

II. REMOVAL OF OIL FROM WATER

Whether the oil is contained or free, it still must be cleaned up to prevent further environmental damage. Although there are many elaborate techniques for oil removal, some simple and non-technical methods are still widely used.

A. Removal by burning

1. Remove the string from your lake. Pour 5 ml of oil on the water surface.
2. Put on safety glasses and light your alcohol burner. Set fire to the tip of a wooden splint. Try to ignite the oil spill with the splint.
3. Does the oil burn? If so, how long did it burn? Was there any oil left when the flames went out? If the oil did not burn, try to explain why.
4. If the oil could be burned, what other damage to the environment might occur?
5. Is the burning of the oil an effective way to clean up an oil spill? Explain.

Containment

3. The string should contain the oil. If too much oil is added, however, it will overflow the boom. You may want to adjust the amount of oil students add. For lighter oils, spreading is greater, and you should decrease the amount used.
4. Answers will depend on how thorough the students are. Most of the oil can probably be removed, but it will be mixed with water. Further treatment would be necessary before the oil could be reused.

Removal by burning

3. The oil should not burn. In trying to explain why, students may explain that "it is wet." In reality, the oil will not burn, because it is a type that does not contain flammable substances. Petroleum fractions are separated with their uses in mind. Some contain volatile mixtures, while others (like this oil) are mostly inert.
4. If the oil burned, damage might occur in the form of air pollution.
5. No. Not all types of oil will burn, and if they do burn they could cause other environmental damage.

B. Removal by sinking

Ordinarily, oil floats on water because it is not as dense as water. Increasing the oil's density will make it sink to the bottom.

1. If your oil was cleaned up in Procedure A, add 5 ml of new oil to your lake.
2. Sprinkle enough sand on the oil spill to cause it to sink. Does this method remove all (or most) of the oil from the surface?
3. When this method is used, what other effects will it have on the environment?
4. What should you know about the water environment before using this method to clean up a real oil spill?
5. Is sinking a good way to clean up an oil spill? Explain.

C. Removal by adsorption

Certain materials will attract oil to their own surfaces. This is called **adsorption.** You have probably seen pictures of this type of clean up method.

1. Pour 5 ml of new oil into your lake. (You do not need to dump the oily sand from B unless it is piled high enough to break the water surface.)
2. Place a small amount of straw on top of the oil. What happens?
3. How can you remove the oil from the lake now? Check your idea with your teacher, and try the idea if the teacher approves. Did your idea work?
4. Is adsorption a good way to clean up an oil spill?

Removal by sinking

2. Most of the oil will sink when sand is added. However, if left standing the oil may escape and bubble to the surface again.
3. Bottom organisms could be smothered. Contaminants could be trapped in the bottom sediments so that future burrowing animals would be poisoned.
4. You should know what bottom organisms you would damage and whether the oil is light enough to surface again.
5. No. There is too much potential for damaging bottom organisms (such as shellfish) and no promise of permanent oil removal.

Removal by adsorption

2. Oil sticks to all the surfaces of the straw.
3. Picking up the straw or burning the straw are the most frequent suggestions. Both work fairly well, especially if clean straw is added and removed several times.

   NOTE: If students wish to burn the oily straw, this activity should be supervised outdoors. Black greasy smoke may result. If clean motor oil has been used, however, it will not ignite.
4. This is a better way than most, especially if the oily straw is mechanically removed instead of burned. In reality, the oily straw would probably be hauled to a land fill, where it will again be a contaminant.

D. Removal by detergents

Household detergents are used to remove oil from laundry or grease from dishes. They do this by breaking up oil drops and dispersing them in the water to form an emulsion.

1. Dump the contents of your lake in the container provided by your teacher. Wipe the lake basin out and add fresh water.
2. Add one drop of oil and one drop of liquid detergent to the lake. Stir the two together vigorously with a wooden splint. What happens?
3. Does dispersion by detergents let you clean up the oil easier? Explain.
4. How could the environment be damaged by use of detergents?

In actual use, detergents are designed to allow natural clean-up to take place more easily. Clean water would not be noticeable until later, as compared to the other clean-up methods.

Removal by detergents

2. A milky suspension is formed. Neither drop is visible any more.
3. This method does not clean up oil. It only breaks it up into tiny droplets that are not as noticeable. Detergents are sometimes used in this way to speed up natural dispersal.
4. The detergents could harm water animals and reduce the "waterproof" characteristics of ducks and other water birds.

RESOURCES

National Response Center: 1-800-424-8802. See http://www.glc.org/docs/advisor/95/oil/report.html – a list of phone numbers for states.

The Internet has many valuable resources for learning more about oil spills in the Great Lakes and other areas. Several organizations help respond to oil spills including the U.S.E.P.A., Great Lakes Commission and Great Lakes Information Management Resource (GLIMR, Government of Canada). For example:

http://www.glc.org/docs/advisor/95/oil/spills.html – the Great Lakes Commission, Advisor – March/April 1995. Oil spills in the Great Lakes Basin: Response and prevention.

See also http://www.glc.org/projects/conting/conting.html – the Great Lakes Commission compiles data on sensitive areas and assists with area contingency planning.

http://www.epa.gov/superfnd/oerr/er/oilspill/response.htm – U.S.E.P.A. Oil Spill Prevention, Preparedness and Response: Responding to Spills; see also http://www.epa.gov/superfnd/oerr/er/oilspill/freshwat.htm – Sensitivity of Freshwater Habitats.

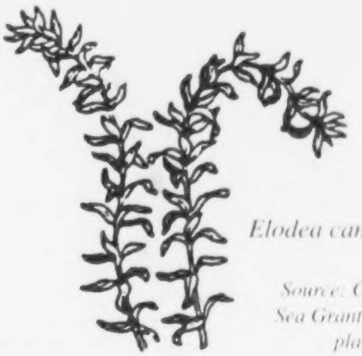
http://www.great-lakes.net/pollution/emerg.html – Oil and Hazardous Materials Spills in the Great Lakes: Emergency, Planning and Response – lists agencies, area contingency plans and other sites.

How does an oil spill affect living things ?

We have all seen pictures of oily sea birds and heard horror stories of damaged fishing grounds resulting from oil spills. The effects of oil are not always so obvious. In this activity you will investigate how oil changes the water and affects plant functions.

OBJECTIVES

When students have completed this investigation, they should be able to describe the effects of oil on aquatic organisms.



Elodea canadensis (water weed).

Source: Charles E. Herdendorf, Ohio Sea Grant Program, Common aquatic plants of the Lake Erie Islands.

PROCEDURE

A. *Changes in water and plant characteristics.*

A group of students did an experiment to find out if oil does anything to water and aquatic plants. They covered two jars with black paper so that light could only get in from the top, as it would in a lake. Then they got some *Elodea*, a water plant, and cut off two pieces that were the same length and had the same number of leaves. One piece of *Elodea* was placed in each jar of water. The students decided to observe changes in the appearance of the plants and study two characteristics of the water. They checked the water for dissolved oxygen (D.O.) since they knew that plants and animals take in oxygen during respiration.

1. Why is the D.O. test important in a study of bodies of water and life in the water?

They also checked for the amount of acid in the water by measuring the "pH." A pH number of less than 7 means the water is acidic. The lower the pH number, the more acid the water is.

2. The amount of acid in the water is related to a gas produced by plants and animals during respiration. What is this gas?

Materials

If done as a "dry lab," only the data chart is required. D.O. measurement (Winkler method) is time consuming and requires numerous dangerous chemicals, so actually doing the experiments in class is not recommended unless you have a digital D.O. meter. You may wish to demonstrate the processes yourself, in which case you would need pH test paper (range 5-9) and a field test kit for D.O. Such kits include pre-measured packets of chemicals so that precision is high and danger to users is minimized.

If a lab option is selected you will also need:
- 250 ml beaker.
- Water.
- 10 ml oil.
- Short piece (5-6 cm) of aquarium plant (*Elodea* or *Anacharis*).

Source

Modified from OEAGLS EP-12 *Oil Spill*, Activity C by Stephanie Ihle and Rosanne W. Fortner.

Earth Systems Understandings

In this activity, students investigate the effects of oil spills using an experiment (ESU 2 and 3 – stewardship and scientific process) simulating the interactions between oil in water and living organisms (4 – interactions).

Answers

1. Living things must have oxygen for respiration. Low levels of oxygen in the water can cause death.

2. Carbon dioxide is produced during respiration.

	Clean Water (Jar 1)		Oil Spill (Jar 2)	
Day	D.O. (ppm)	pH	D.O. (ppm)	pH
1	10	7	10	7
2	10	7	9	7
3	10	7	7	6
4	10	7	4	5

The D.O. and pH in both jars were measured on the first day of the experiment and recorded in the chart above (Day 1). Then the students created an oil slick in one of the jars. They used motor oil like the kind that is used in cars. On the next 3 days they repeated their D.O. and pH tests and recorded the results in the chart (Days 2, 3 and 4).

3. In which jar did D.O. decrease? In which jar did it stay the same? How can you explain this?

4. The pH in the oil spill went down. If both plants were making the gas you named in Question 2, why did the pH drop in one jar and stay the same in the other?

Photosynthesis in plants requires sunlight, water, and carbon dioxide. Respiration requires oxygen.

5. Can the plant in the oil spill get light? Water? Carbon dioxide? Oxygen?

6. Can the plant in clean water get light? Water? Carbon dioxide? Oxygen?

7. How does an oil spill affect photosynthesis in plants? Respiration?

The students decided to find out if oil was harmful when it got right on the plant itself, so they dipped a piece of Elodea in oil and put it in a cup of clean water. Some of the oil floated off, but the leaves remained coated.

8. Could the leaves of the plant get light? Water? Carbon dioxide? Predict what happened to the oily plant.

You may wish to repeat the experiment if time allows. How do your data and observations compare to the data in the table?

Answers

3. D.O. decreased in the oil spill jar but stayed the same in the clean jar. The plant's respiration is using up the oxygen dissolved in the water, and oxygen is no longer available from the air above the water surface. The plant makes oxygen during photosynthesis, but no light is available for this process.

4. In the clean tank, extra carbon dioxide (CO_2) can escape into the air. The CO_2 produced by plant respiration in the oil jar stays in the water and causes the water to become more acidic

   $CO_2 + H_2O = H_2CO_3$
   (Carbonic Acid)

5. Light - no; Water - yes; Carbon dioxide - yes and Oxygen - yes, but only what is in the water.

6. Light - yes; Water - yes; Carbon dioxide - yes and Oxygen - yes.

7. Photosynthesis decreases because there is not light penetrating the water. Carbon Dioxide is available, but the process cannot go on without light. Respiration fails without oxygen.

8. Light - no; Water - no and Carbon dioxide - no. The plant died within a short time.

B. Changes in animal populations

The U.S. National Academy of Sciences has listed the findings of scientists about the effects of oil spills on animals.

1. Petroleum products do not remain in marine organisms after the spill has gone. These products are not concentrated as they pass through the food chain. In the Great Lakes, on the other hand, some organisms do accumulate petroleum materials in their fat.

2. Oil on beaches damages shoreline life. Oil seeps downward into sand and remains there for years. Rocky shorelines can clean themselves naturally through wave action; but bays, estuaries, and marshes have few waves. Oil spills in such areas are very damaging.

3. Oil causes serious harm to birds by coating their feathers. An oily bird does not float, and it has no insulation against temperature changes. Birds also poison themselves by ingesting the oil that coats them.

4. Oil is sometimes responsible for smothering communities of animals that live on the sea floor. This is especially important to the shellfishing industry. Most of these areas will eventually become settled again, but some organisms like mussels cannot survive in an oiled area.

In the Great Lakes, the fresh water cannot hold the heavier types of oils on the surface. The oil sinks and enters the bottom sediments and the food chain.

5. Fish are not affected by oil pollution as much as other organisms. A massive spill such as that from the *Amoco Cadiz* in 1978 can kill large numbers of fish, but ordinarily fish are able to escape injury from minor accidents.

6. Different petroleum products have different effects on organisms. Diesel or heating oils are most poisonous, while heavy crude and fuel oils are worse for smothering animals. Oil may be more poisonous to freshwater organisms than to sea life, probably because cold lake water slows down evaporation and oils stay in the environment longer.

Answers

1. Since ocean water contains salt, it is more dense and buoys up the less dense oil. In the fresh water of the Great Lakes, some oil fractions are heavier than water and will sink to the bottom.

2. The spill would have to be of great extent, covering large areas of surface water. Sunlight and oxygen are prevented from entering the water.

3. Diesel and heating oils poison living things, while heavy crude and fuel oils smother animals.

4. No. Different coastal features are affected differently. Rocky shores and heavy wave action break up oil. Rocks do not absorb oil, but plants, sand and mud in bays and estuaries do absorb it. Areas with little wave action hold spills.

5. The water is usually colder, so less evaporates, and it flows more slowly so that the oil is slower to disperse naturally.

Answers to Review Questions

1. Runoff from rivers and cities and tanker operations are the major sources of oil pollution in the marine environment.

2. Wind and currents spread the oil out. Some of it evaporates, and some is consumed by bacteria called petrophiles.

3. Oil may be removed by adsorption, burning, sinking, and detergents. Students should list three of the four ways.

4. Three of the four answers below.
   Adsorption: If adsorbent is mechanically removed, little environmental damage occurs. If burned, however, it creates air pollution.
   Burning: Causes air pollution.
   Sinking: Lightweight oils will resurface. Heavy oils may smother bottom organisms and trap contaminants in bottom sediments.
   Detergent: Does not really remove oil, but speeds natural processes of clean-up. Could harm water animals and reduce "waterproof" characteristics of shore birds.

Answer these questions based on your reading of Part B:

1. Why does the oil spilled in the Great Lakes sink to the bottom, while oil on the ocean floats.

2. Describe an oil spill that could kill large numbers of fish.

3. What kinds of petroleum products have the greatest effect on organisms? How do these affect the organisms?

4. Are all areas of the coastline affected in the same way by oil pollution? If not, explain differences.

5. Why does oil remain in Great Lakes water longer than in ocean water?

REVIEW QUESTIONS FOR ALL OIL ACTIVITIES

1. What are the two major sources of oil pollution in the oceans?

2. How does nature clean up oil spills?

3. List three ways that oil can be removed from water.

4. For the methods you listed in #3, what damage to the environment might occur if these methods are used?

5. How does oil affect plants? Birds? Bottom animals? Fish?

5 Plants coated with oil die without light, water, and gas exchange. Plants beneath an oil slick will also die for lack of light.

Birds with oily feathers will drown, die of exposure, or poison themselves by eating oil. Bottom animals may be smothered. Fish can usually swim away to unaffected areas, but their food supplies and breeding grounds may be damaged.

EXTENSION

What would clean-up crews have to address in their efforts? List the organisms that would need help after a spill event. Do research on the training required for cleaning up oil spills.

REFERENCES

Baker, J.M, R.B. Clark, and R.H. Jenkins. 1990. *Natural Recovery of Cold Water Environments After an Oil Spill.* Anchorage: Exxon Alaska Operations. Phone: (907) 546-3612.

Mickelson, Belle. etal. 1990. *Alaska Oil Spill Curriculum.* Cordova, Alaska: Prince William Sound Science Center. Phone: (907) 424-5800.

Satchell, Michael and Betty Carpenter, Sept. 18, 1989. A disaster that wasn't. *U.S. News and World Report,* p. 60.

Steiner, Rick and Kurt Byers, 1990. *Lessons of the Exxon Valdez.* Fairbanks: Alaska Sea Grant College Program. SG-ED-08. Phone: (907) 474-7086.

"Oil Eaters," *Time Magazine* 106:46. September 22, 1975. Tells of discovery of bacterial genus of petrophiles. Research on effects.

Students may want to investigate the Oil Pollution Act of 1990, which was initiated as a response to the Exxon *Valdez* Oil Spill.

INTERNET SITES

Great Lakes Environmental Sensitivity Atlases and Digital Database. Source: Government of Canada, http://www.cciw.ca/glimr/metadata/enviro-sensitivity-atlas/intro.html

Oil Spill Public Information Center – http:// www.alaska.net/~ospic/index.html

Southeastern Michigan Contingency Planning Sub-area, Great Lakes Commission Advisor, March/April 1995 – http://www.glc.org/docs/advisor/95/oil/sub-area.html

U.S.E.P.A. Oil Spill Prevention, Preparedness and Response Web site http://www.epa.gov/superfnd/oerr/er/oilspill/oilhome.htm for more information – oilinfo@epamail.epa.gov

What if.... (a Great Lakes Investigation)

We know that the water in the Great Lakes is not stationary. It is in constant motion throughout the lake. How does the water move within a lake? How will this movement affect the flow of materials that come into the lake? To answer these and other questions, we need to know how water is currently moving about within a lake. A good source of the information is the *Great Lakes Forecasting System*, available on the Internet for Lake Erie and for the other Great Lakes in the future. Using the information available there and in other locations on the Internet, it is possible to construct a model of how materials move about within the lakes. For instance, we can begin to answer questions about how pollutants might move.

OBJECTIVE

During this activity you will:

- Develop increasing awareness of available data sets and how to use them.
- Design strategies for predicting the potential hazards that may develop within the Lake Erie Basin.
- Develop an understanding of the use and power of computer tools.
- Practice the skill of working with others.
- Evaluate strategies for clean-up of described pollution.

PROCEDURE

A. Consider the following:

An oil-carrying tanker sank off the coast of Lakewood, Ohio, on Lake Erie in the 1950s. Recent investigation has revealed that the hull is deteriorating and may begin leaking. Salvage efforts have begun for removing the oil from the tanker. During these efforts machinery slips and ruptures the hull completely. Oil begins gushing from the tank and approximately 150,000 gallons spill before being controlled.

B. Using maps, the Internet and any other tools available to you answer the following questions based on conditions in Lake Erie.

1. Where is Lakewood on the map?
2. Where can we get information to find out the effect of this spill?
3. Will the municipal water intakes of Cleveland, Vermilion, Huron, etc., be affected by the spill?
4. Who else will be affected by this event?
5. What weather factors might affect this?
6. What government agencies and officials might you contact for further information?
7. What effects could the spill have on wildlife in the area?

Materials

- Access to the Internet.
- Maps (Ohio, Great Lakes Basin, Lake Erie).
- Data Sets (electronic or paper)

Earth Systems Understandings

This activity is related to ESU 2 (stewardship), 3 (scientific process), and 4 (interactions) as students investigate potential scenarios caused by human actions.

Source

Modified from "What if .... (a Great Lakes Investigation) by Karen Oberst, University of Findlay, Findlay, OH.

Great Lakes Forecasting System

http://superior.eng.ohio-state.edu/

For more information or a GLFSVIEW Windows disk contact
Department of Civil Engineering
The Ohio State University
470 Hitchcock Hall
2070 Neil Avenue
Columbus, Ohio 43210
(614) 292-6589

C. Using the information you discovered, construct an emergency contingency plan for dealing with the situation. Cover the basics – Who (will you employ, notify, etc.), What (will you do), When (time-frame), Why (support your choices).

EXTENSIONS

Use the following scenarios to answer the questions in procedure Part B (the questions will need to be modified somewhat because they are site specific).

1. What if an industrial process on Lake Erie malfunctions and sends heated water into the Lake? Where will the water go? Compare its impact in spring and in summer.

2. What if a pleasure boat and barge collide on the Lake? In what direction would you search for floating debris? Is that always the same direction?

3. A group of students on a camping trip write special verses and good wishes that they want to share with others. They write their works on scraps of cloth that they use for sails on homemade boats, and they release the boats from Fish Point at the tip of Pelee Island. On the basis of Great Lakes Forecasting System (GLFS) data for a day you choose, predict where the boats might wash ashore. Justify your answer.

Framework for Earth Systems Education

UNDERSTANDING #1: Earth is unique, a planet of rare beauty and great value.

- The beauty and value of Earth are expressed by and for people of all cultures through literature and the arts.
- Human appreciation of Earth is enhanced by a better understanding of its subsystems.
- Humans manifest their appreciation of Earth through their responsible behavior and stewardship of its subsystems.

UNDERSTANDING #2: Human activities, collective and individual, conscious and inadvertent, affect Earth systems.

- Earth is vulnerable, and its resources are limited and susceptible to overuse or misuse.
- Continued population growth accelerates the depletion of natural resources and destruction of the environment, including other species.
- When considering the use of natural resources, humans first need to rethink their lifestyle, then reduce consumption, then reuse and recycle.
- Byproducts of industrialization pollute the air, land, and water, and the effects may be global as well as near the source.
- The better we understand Earth, the better we can manage our resources and reduce our impact on the environment worldwide.

UNDERSTANDING #3: The development of scientific thinking and technology increases our ability to understand and utilize Earth and space.

- Biologists, chemists, and physicists, as well as scientists from the Earth and space science disciplines, use a variety of methods in their study of Earth systems.
- Direct observation, simple tools, and modern technology are used to create, test, and modify models and theories that represent, explain, and predict changes in the Earth system.
- Historical, descriptive, and empirical studies are important methods of learning about Earth and space.
- Scientific study may lead to technological advances.
- Regardless of sophistication, technology cannot be expected to solve all of our problems.
- The use of technology may have benefits as well as unintended side effects.

UNDERSTANDING #4: The Earth system is composed of the interacting subsystems of water, rock, ice, air, and life.

- The subsystems are continually changing through natural processes and cycles.
- Forces, motions, and energy transformations drive the interactions within and between the subsystems.
- The Sun is the major external source of energy that drives most system and subsystem interactions at or near the Earth's surface.
- Each component of the Earth's system has characteristic properties, structure, and composition, which may be changed by interactions of subsystems.
- Plate tectonics is a theory that explains how internal forces and energy cause continual changes within Earth and on its surface.
- Weathering, erosion, and deposition continuously reshape the surface of the Earth.
- The presence of life affects the characteristics of other systems.

UNDERSTANDING #5: Earth is more than 4 billion years old, and its subsystems are continually evolving.

- Earth's cycles and natural processes take place over time intervals ranging from fractions of seconds to billions of years.
- Materials making up Earth have been recycled many times.
- Fossils provide the evidence that life has evolved interactively with Earth through geologic time.
- Evolution is a theory that explains how life has changed through time.

UNDERSTANDING #6: Earth is a small subsystem of a Solar system within the vast and ancient universe.

- All material in the universe, including living organisms, appears to be composed of the same elements and to behave according to the same physical principles.
- All bodies in space, including Earth, are influenced by forces acting throughout the solar system and the universe.
- Nine planets, including Earth, revolve around the Sun in nearly circular orbits.
- Earth is a small planet, third from the Sun in the only system of planets definitely known to exist.
- The position and motions of Earth with respect to the Sun and Moon determine seasons, climates, and tidal changes.
- The rotation of Earth on its axis determines day and night.

UNDERSTANDING #7: There are many people with careers and interests that involve study of Earth's origin, processes, and evolution.

- Teachers, scientists, and technicians who study Earth are employed by businesses, industries, government agencies, public and private institutions, and as independent contractors.
- Careers in the sciences that study Earth may include sample and data collection in the field and analyses and experiments in the laboratory.
- Scientists from many cultures throughout the world cooperate and collaborate using oral, written, and electronic means of communication.
- Some scientists and technicians who study Earth use their specialized understanding to locate resources or predict changes in Earth systems.
- Many people pursue avocations related to planet Earth processes and materials.

The development of this framework started in 1988 with a conference of educators and scientists and culminated in the Program for Leadership in Earth Systems Education. It is intended for use in the development of integrated science curricula. The framework represents the efforts of some 200 teachers and scientists. Support was received from the National Science Foundation, The Ohio State University, and the University of Northern Colorado.

For further information on Earth Systems Education, contact the Earth Systems Education Program Office, 2021 Coffey Road, The Ohio State University, Columbus, OH 43210.

http://earthsys.ag.ohio-state.edu

SAMPLE RUBRIC

The rubric was developed by an Earth Systems teacher for use in evaluating individual student research projects.

RESEARCH TIME UTILIZATION	The student needed continual reminders to get back to work. Work may be inappropriate to the project.	The student was usually on task, but needed an occasional reminder to get back to work. All work is appropriate.	The student was always on task and did not need reminders to get back to work.
PARTICIPATION IN PROJECT	The student does not add an equitable amount of work to the project and does not meet all requirements for the length of presentation.	The student adds an equitable amount of work to the project, but may not meet all requirements for the length of the presentation.	The student adds an equitable amount of work to the project and meets all requirements for the length of the project.
ACCURACY OF INFORMATION DURING PRESENTATION	The student's information was lacking in content and was not factually correct in many places. Information may not be pertinent to the presentation.	The student's information is for the most part factually correct. Information may not be pertinent to the presentation.	The student's information is factually correct and pertinent to the presentation.
CLARITY OF PRESENTATION	The student's work is not well planned. The student was confused by much of the information presented. The student was not clear in explaining topics.	The student's work is well planned. There seemed to be some confusion or misinterpretation of information.	The student's work is well planned and clearly explained. The student showed a clear command of the information presented.
VISUAL AID, WORKSHEET, OR SIMPLE DEMONSTRATION	The device used by the student was not used at a timely place in the presentation, had little bearing on the presentation, or was absent from the presentation.	The device used by the student was appropriate for the presentation. It may have been used in a more appropriate manner. The design of the device may not have maximized the learning.	The use of the device was timely and appropriate. The design of the device was constructed to maximize learning.

Source: Mayer, V.J. and R.W. Fortner, 1995. *Science is a Study of Earth: A resource guide for science curriculum restructure*. Columbus, OH: Earth Systems Education Program, The Ohio State University

Other ES-EAGLS

GREAT LAKES CLIMATE AND WATER MOVEMENT

Water Movement

- How does water move in the Great Lakes basin?
- How long does it take water to flow through the Great Lakes?

Temperature and Climate

- What happens to heat energy reaching the Great Lakes?
- What causes the land-sea breeze?
- How do the Great Lakes affect temperature?
- How is weather influenced by the Great Lakes?

Lake Levels and Storms

What causes storm surges?

- How do storm surges affect water levels on Lake Erie?
- How do the levels of the Great Lakes change?
- What would be the result of regulating the level of one of the Great Lakes?

Seasons on the Great Lakes

- How do the Great Lakes change through the seasons?
- How does stratification affect water quality?
- What factors impact ice coverage on the Great Lakes?

GREAT LAKES SHIPPING

Great Lakes Shipping

- What products are carried on the Great Lakes?
- What is the most economical form of transportation?
- Which transportation method uses the least energy?

World Connection

- Where go the boats?
- How do ships go from one lake to another

Language

- How have ships and sailing influenced our language?

Great Lakes Triangle

- What is the Great Lakes Triangle?
- How can disappearances within the Triangle be explained?
- What happened aboard the *Edmund Fitzgerald*?

Canals

- How were early canal routes determined?
- How did the canals affect Ohio?

LIFE IN THE GREAT LAKES

Organisms in the Lakes

- How does a dichotomous key work?
- What are the characteristics of some Great Lakes fish?
- How do fish get their names?
- How are shorebirds adapted for feeding?
- What do scientists know about invader species of the Great Lakes?

Ecological Relationships

- Who can harvest a walleye?
- What does a biomass pyramid tell us?
- What is a food web?
- What factors affect the size of a natural population? (A Great Lakes fish example)
- How can a natural fish population be managed?

Estuary Values and Changes

- What is the role of plants in an estuary?
- How does the estuary serve as a nursery?

LAND & WATER INTERACTIONS IN THE GREAT LAKES

Geography and Technology

- How well do you know the Great Lakes?
- What can GLIN tell us about land and water interactions?

History of Land and Water Interactions

- When did the rocks in the Great Lakes basin form?
- How were sedimentary rocks in the Great Lakes basin formed?
- How did rocks and rivers shape the Great Lakes?
- What evidence of glaciation exists in the Great Lakes region?
- What evidence of glaciation and geologic processes can be found on Great Lakes beaches?

Land and Water Interaction Today

- What causes the shoreline to erode?
- Can erosion be stopped?
- How fast can a shoreline change?
- How much land has been lost?
- What natural wonders of the Great Lakes relate to land and water interactions?
- How can a concept map represent land and water interactions?

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180